

# Microbiological and physiochemical analysis of drinking water in Georgetown, Guyana

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**Abstract:** To determine microbial and physio-chemical analysis of water samples and biofilm samples taken from residential and GWI sites of Georgetown, Guyana. Physio-chemical analysis includes analysis of pH, total chlorine, and turbidity, COD, BOD and total Iron. Microbial analysis includes the presence of different microbes in biofilm as well as water samples within sites. Overall the most prevalent species in biofilm and water samples within the study was *Lactobacillus* sp. while the least prevalent species was *Salmonella* sp. [Nature and Science 2010;8(8):261-265]. (ISSN: 1545-0740).

**Key words:** Microbiological analysis, physiochemical analysis, water

## Introduction

Drinking water quality has always been a major issue in many countries, especially in developing countries (Assembly of Life Sciences, 1977). The World Health Organization in its "Guidelines for drinking water quality" publication highlighted at least seventeen different and major genus of bacteria that may be found in tap water which are capable of seriously affecting human health (WHO, 2006). The proportion of waterborne disease outbreaks associated with the distribution system failures has been increasing over the years (Moe & Rheingans, 2006).

Biofilm is also a subject of interest in recent years due to the predominance of biofilm-associated bacteria in natural environments, the complex developmental pathway that bacteria follows in forming a biofilm, and the role of biofilm formation in antibiotic-resistant bacterial infections (Davey & O'Toole, 2000; Mah & O'Toole, 2001). Biofilms in distribution systems may provide a favorable condition for some bacteria, such as opportunistic pathogens (e.g., *Legionella* spp., *Pseudomonas aeruginosa*, and *Mycobacterium avium*), to colonize and may harbor pathogens, such as *Salmonella enterica* serovar Typhimurium, which can enter the distribution system (Berry et. al., 2006; Parsek & Singh, 2003).

The Guyana Water Inc (GWI) supply potable water to over 145,000 customers in Guyana with more than 300,000,000 liters of potable water per day. GWI has water treatment plants at various places throughout Guyana, including Sophia, Better Hope, Covent Garden, Eccles, Number 56 Village, Bartica, Bel Air Park and Mon Repos. Its sources of water include ground water from wells and also surface water from areas such as Linden and at the Shelter belt (GWI website). A "water resources assessment of

Guyana" produced by the United States Southern Command, found that "water distribution systems in Georgetown are poorly maintained and unreliable, forcing most residents to use individual cisterns." (Water Resources Assessment of Guyana, 1998). It is also not uncommon for GWI to issue boil water advisories to the public when water supplies have been contaminated. The United Nations Children Fund (UNICEF) rates Guyana as having 94% coverage/supply of drinking water; this represents one of the highest in the Latin America & Caribbean region (UNICEF, 2001). The question of water quality is, however, not sufficiently addressed.

Therefore, this study aims to detect the presence of microbes in water samples and biofilm samples giving emphasis to pathogenic species in the samples. This study also analyzes the physio chemical status of both residential tap water and water at treatment plant of Guyana.

## Materials and method:

**Sampling Sites:** Water samples from different sources and sites in the municipality area of Guyana was collected during the year 2009. Eight locations were selected from which 12 sample sites were derived. Sampling was conducted at (Source) Guyana Water Incorporation's (GWI) shelter belt location at Vlissengen Road where five (5) sample sites were identified – Raw water source (i.e. Lamaha canal/Black water), Treated water (i.e. water treated with Alum and Lime), Clarified canal water also known as Clarified water, Flume water (i.e. water taken directly from the fast flowing (flume) drain and Distribution water (i.e. water that GWI distributes to consumers). Sophia (Well) Water Treatment Plant and Central Ruimveldt (Well) Water Treatment Plant represented the other source sample sites.

Tap water was collected from different residential sites located in West La Penitence and Albouystown – 2 wards in South Georgetown, Kitty- a section of North Georgetown, Sophia – a regularized squatter settlement in Georgetown and Wortmanville – a highly populated section of South Georgetown were also sampled.

**Sample Collection:** Water and biofilm samples were collected for both physiochemical and bacteriological analysis. Samples were collected during the day between 9:00 hrs and 13:00 hrs. Water samples for physiochemical and bacteriological analysis were collected aseptically in sterile containers and placed in a cooler at room temperature and transported to the National Public Health Reference Laboratory (NPHRL) for analysis within 2 hours from collection. Biofilm samples were collected and placed in tubes containing transport media and transported to NPHRL for analysis.

**Laboratory sites:** Tests for total Iron, BOD and COD and Coliform tests were conducted at Demerara Distiller's Limited Central and Microbiology Laboratory located at Plantation Diamond, East Coast Demerara. Bacteriological analysis (identification of bacterial species) was conducted at National Public Health Research Lab located in the Georgetown Public Hospital Corporation (GPHC). Total Chlorine, pH and turbidity tests were conducted at the Food and Drugs Department of the Ministry of Health located at Turkeyen.

**Materials:** Isolation of bacteria from water sample and biofilm swab was done using R2A agar, Blood agar and Nutrient agar. Other methods/media used were Gram's stain, Difco triple sugar iron agar, Difco simmons citrate agar slant, Difco sulfide Indole motility (SIM), Difco Urea agar base, Difco Lysine Iron Agar (LIA), Difco Phenylalanine agar ferric chloride reagent, Difco cystine tryptic agar (CTA) medium with Sorbitol, Difco Malonate Broth, Oxidase test, Catalase test, Difco Bile Esculin Agar, Bio Merieux API-20E. The presence of total coliform was enumerated using 5m Endo Agar LES.

The methods to detect the chemical composition of water was done using HACH total Chlorine DPD powder pillow method, HACH turbidity using Hach 2100P Turbidimeter, Mettler Toledo used in measuring pH in aqueous solution, Atomic Absorption Spectrometry to detect total Iron, Respirometric Method using BOD Trak apparatus for detecting Biochemical Oxygen Demand (BOD), COD HACH to detect Chemical Oxygen Demand (COD).

## Results:

### Physiochemical analysis

The table presents physiochemical analysis of all water samples collected from residential area tap water and the Guyana water Inc. (Table 1). Analysis of sample showed high levels of turbidity, BOD, COD, and total Iron in Albouystown whereas pH was high in Wortmanville. La Penitence recorded high level of total chlorine. GWI water samples recorded high levels of total chlorine and turbidity in Treated water sample. Sophia well sample recorded high levels of COD, BOD and total Iron whereas Clarified water had high pH units.

Table 2 shows correlation among different parameters in the physiochemical analysis. Significance was shown between turbidity and total chloride level and with pH to turbidity and total chloride. Presence of bacteria had correlation with other parameters ANOVA 0.968,  $p=0.5$ . Relation of BOD and COD with that of bacteria also shows a significance with  $t=-1.045$  for COD,  $p=0.336$  and  $t=0.205$ ,  $p=0.844$ .

### Microbiological analysis

Total microbiological analysis of water and biofilm samples from residential sites and GWI sites are shown in Table 3. All the samples showed presence of microbes with a total of 12 species of bacteria detected from both biofilm and water samples processed at NPHRL. *Acinetobacter sp.*, Coagulase Negative *Staphylococcus sp.*, *Lactobacillus sp.*, Non-hemolytic *Streptococcus sp.*, *Chromobacterium sp.*, *Flavobacterium sp.*, *Pasteurella sp.*, *Salmonella sp.*, *Providencia sp.*, *Micrococcus sp.*, *Pseudomonas sp.* and *Bacillus sp.* Most predominant microbe isolated was *Acinetobacter sp.* (24.6%) and *Lactobacillus sp.* (25.2%).

Figure 1 represents the number of species isolated from biofilm samples and water sample from GWI and residential sites. Analysis of biofilm samples collected from different residential sites and GWI is shown in table 4. Among GWI sites distribution water had highest prevalence of microbes with 13.8% followed by Central Ruimveldt Well with a prevalence of 12.6%. Within residential sites, Sophia pipe line recorded highest prevalence of total microbes (10.8%) followed by Albouystown with (10.6%). Biofilm sample isolated from Kitty had lowest prevalence of total microbes with 4.4% whereas treated water sample from GWI had lowest prevalence (1.6%).

Analysis of water samples collected from different residential sites and GWI is shown in table 5. Within residential sites highest prevalence of microbes was isolated from La Penitence tap water with 9.7% followed by Sophia tap water with 7.6%. Within GWI

water samples highest prevalence of microbes was isolated from Sophia well with 18.1% whereas clarified water sample had second most prevalence with 17.4%. Lowest prevalence of microbe was recorded in Kitty tap water (2.8%) among residential site whereas in GWI samples, treated water (2.1%) and Flume water (2.1%) samples recorded lowest.

### Discussion

This study has presented the physiochemical and microbiological analysis of water samples and biofilm samples taken from different residential area and from Guyana Water Inc.(GWI). GWI supplies water to most part in and around the capital Georgetown.

The physiochemical analysis report presents values of parameters below the standards of WHO. Turbidity was high in all the tested samples. Turbidity represents an important aspect of water quality. It is deemed as the cloudiness of a liquid as a result of particulate matter being suspended within it. Its importance is highlighted by the fact that suspended solids interfere with effective chlorination/disinfection and helps to shield bacteria (Asano, 2007). Additionally, suspended solids also serve as a place of attachment for bacteria (Hurst, 1996). The general WHO standard set for drinking water is a turbidity <0.1 NTU. A turbidity >5 NTU is considered unhealthy.

For effective chlorination, pH should be less than 8.0 and this must be controlled so as to minimize corrosion of water mains and pipes. The WHO Guidelines for drinking water quality states that the pH range of drinking water should fall between 6.5 and 8.0. The current study found raw water and treated water with pH 5.9 and 5.5, which were water samples taken very early in the treatment process. Generally low pH values obtained in the water might be due to the high levels of free CO<sub>2</sub> which may consequently affect the bacterial counts (Edema et al., 2001).

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are used to measure oxygen used and equate it to the amount of organic matter within the water sample. BOD measures the amount of oxygen used by microorganisms, in this case bacterium, to oxidize organic matter present within the water sample (Nielsen, 2003). Water with BOD levels <4mg/L are deemed as clean, while those >10 mg/L are considered polluted and unsafe. This study reported La Penitence, Albouystown, Sophia, Treated water and the Sophia well had BOD levels >10 mg/L whereas Albouystown was the only site to have higher levels of COD.

COD is used to measure the oxygen equivalent of organic matter of a sample and uses a chemical

oxidant COD values should be <10 mg/L at the end of treatment of water.

Iron is known to promote the growth of iron bacteria in water and also makes the water distasteful. Apart from its unpleasant taste, iron forms rust in water and it can cause clogs and stains pipes. WHO states that below 0.3mg/L of iron does not affect the taste of water. This study noted that total iron was higher in Albouystown and Sophia well samples. The presence of iron leading to the discolouration of tap water in Guyana is not an uncommon scenario. The Guyana Times of Wednesday, October 29, 2009 carried an article headlined "Princes St. Residents fed up with poor quality water", in which it was stated that residents complained of water flowing through their taps, having a rusty colour and foul odour.

Isolation of pathogenic and potentially pathogenic microorganisms such as *Salmonella* sp., *Staphylococcus* sp., *Aeromonas* sp., *Streptococcus* sp. and *Pseudomonas aeruginosa* is of highly importance and indicated that tap water is unsafe. The isolation of *Pseudomonas aeruginosa* and *Aeromonas* sp. indicated water quality deterioration and that immunocompromised people are in risk and suggested that there may be connection between the high cases of reported diarrhea and the isolated organisms. (Yagoub & Ahmed, 2010)

*Pseudomonas* sp. are very common in water systems due to their ease of colonization and they form thick biofilms which consequently has an effect on turbidity, taste and odour of drinking water (Aquachem & WHO, 2006).

High levels of coliform bacteria were present in water samples taken from both source and point of use. Total coliform counts in most cases were >250 CFU/100mL, this was far above the accepted WHO standard (0 CFU). Wortmanville, Distribution water, Central Ruimveldt well and Sophia well samples did not show such high total coliform counts. Although Coliforms were detected in water samples processed at DDL, no coliforms, inclusive of *Escherichia coli*, were isolated and identified from either the biofilm or water samples processed at NPHRL. This is not unusual since in a study conducted in Italy identified not many coliform colonies in the biofilm and none at all in the matching water samples (Bonadonna et al., 2009). This correlates with another study conducted to detect *E. coli* in biofilm from pipe samples and coupons in drinking water distribution networks (Juhna et al., 2007) which stated that *E. coli* was not detected using traditional culture based methods.

The effects of drinking contaminated water results in thousands of deaths every day, mostly in children under five years, in developing countries (WHO, 2004). In addition, diseases caused through

consumption of contaminated water, and poor hygiene practices are the leading cause of death among children worldwide, after respiratory diseases (WHO, 2003). Thus lack of safe drinking water supply, basic sanitation and hygienic practices is associated with high morbidity and mortality from excreta related diseases.

This study highlighted a few of the many species of bacteria present within the biofilm and water at selected sites within the drinking water network of Georgetown. However, not only pathogenic bacteria may be present within biofilm, but other organisms including protozoa, fungi and even nematodes may be found. The need to explore and understand the microbiota, especially biofilm, within these systems should be emphasized, so as to ensure the delivery of healthy potable water for all.

### Conclusion

This study concluded that water quality distributed at Georgetown need more effort in limiting the numbers of microbial organisms released into distribution systems. Water sample as well as biofilm samples collected from both residential sites and GWI sites presented poor quality both in terms of physio chemical and biological parameters. At present the GWI only focuses on the presence of coliforms as an indicator of water quality because of the limited financial resources of the company and country as a whole. It is recommended that effective management and maintenance are required in order to minimize acute problem of water related diseases, which are endemic to the health of man.

### Acknowledgement

The authors are grateful to the staffs of the microbiology lab at the National Public Health Reference Laboratory and Central lab of Demerara Distiller's Limited (DDL). The authors also thank the staff of the Central Lab of the Food and Drugs Department of the Ministry of Health and the Institute of Applied Science and Technology (IAST) for their kind cooperation.

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8/8/2010