Advances in Science and Technology, Vol. 9, No. 1&2, September / October, 2015, pp 14 - 23

Assessment of Water Quality of Lakes Grenada, Enid, Sardis, and Ross Barnett Reservoir in Mississippi, USA

Julius O. Ikenga[1], Padmanava Dash[2] and Grace C. Ikenga[1]
[1]Department of Natural Sciences & Environmental Health, Mississippi Valley State University, Itta Bena, MS,
[2]Department of Geoscience, Mississippi State University, Mississippi State, MS.
(Submitted: August 20, 2015; Accepted: September 10, 2015)

Abstract

Environmental pollution remains the number one health challenge for freshwater resources. Prior to undertaking field trips, coordinates for 12 sampling sites were set up on a GPS for Lake Grenada (LG), Lake Enid (LE), Lake Sardis (LS) and Ross Barnett Reservoir (RB). Eight field trips were undertaken; two for each of the freshwaters. We collected water samples at depths of 1-5m from a motorboat, using a LaMotte Water Sampler™ and a mobile GPS that located the sampling sites. Two clean 300 ml Nalgene™ bottles were filled with water from each of the sites, capped, labelled and kept chilled at all times and subsequently transported to Water Quality Laboratory at Mississippi Valley State University. Temperature, pH, dissolve oxygen (DO), total dissolved solids (TDS), and salinity were measured in-situ using a HI 9828 Multiparameter meter and probes®. The in-situ mean measurements for the four freshwaters ranged from 25. 65 to 29.89°C for temperature, 6.76 to 7.79 for pH, 5.53 to 8.09 ppm for DO, 21.58 to 34.75 ppm for TDS, and 0.019 to 0.039 ppm for salinity. Qualitative analyses of water samples showed traces of ammonia nitrogen at LE, LS and RB. Traces of chlorine were found at RB and LS, while iron traces were detected at LG, LE, and RB. Phosphorous was found at LE and LS. Silica was positive at all four freshwaters. Coliform bacteria also were detected at all four freshwaters; indicating potential fecal contamination. Copper, Cyanide, Chromium, Nitrate nitrogen and sulfide were not detected in this study. Additional studies are suggested to monitor pathogenic *E. coli* in the freshwaters, as well as to determine the concentrations of the five chemicals found in this study, and how often they impact the freshwaters.

Keywords: Water parameters, Coliform bacteria, in-situ measurements, GPS, Contamination, freshwater, and pollutants.

1.0 Introduction

Living organisms ordinarily abound in non-polluted freshwaters. Environmental pollution negatively impacts the health of freshwaters and the survival of their resident organisms. Lakes Grenada (LG), Enid (LE), Sardis (LS), and Ross Barnett Reservoir (RB) are the four largest freshwaters in Mississippi (MS), after Pickwick Lake (https://www.lakesonline.com/usa/mississippi); serving more than 1 million citizens as the main sources for drinking water, economic growth, and recreational resources for boating, sport fishing, and swimming. Field campaigns data recorded by Dash *et al*., (2012) listed the occurrence of algal blooms, including the harmful algae, cyanobacteria (formerly known as blue-green algae), in all the four freshwaters. Harmful algal blooms (HABs) have been reported to cause water discoloration, turbidity, odor, taste concerns and shielding-out of light from water (Carmichael, 1997; Codd, 2000; Metcalf and Codd, 2004). The presence of cyanobacteria blooms in freshwaters not only degrades the water quality but also negatively impacts the aquatic ecosystem through fish-kills, production of cyanotoxins, and promoting of hypoxic waters (Carmichael, 1997; Garcia 2010 and Mishra *et al*., 2014). Wielding more concerns than the presence of harmful algal blooms (HABs) is the finding of heavy metals, fecal coliform bacteria and cyanotoxin, microcystin, in the freshwaters. Microcystin is a known liver toxicant which promotes health hazards for humans, birds and wildlife that use the contaminated water (Codd *et al*., 1999 and Falconer and Humpage, 2005, https://www.whoi.edu/redtide/impacts/wildlife/birds). Some coliform bacteria represent a wide variety of bacteria that live in the intestines of warm-blooded animals, including humans. The coliform bacteria and other disease-causing bacteria, viruses, and protozoans are associated with fecal matter of warm-blooded animals, including humans (Madigan *et al*., 2015).

Studies have shown that many animals that live in polluted waters end up accumulating the same pollutants from their environments into their tissues; making them less fit and more susceptible to parasitic infections. A study of a watershed pond in Carroll Co. Mississippi found both parasitic and fungal diseases in many fish species (Ikenga and Wagner, 2005). Garcia *et al.* (2010) reported that blue crabs in a Louisiana lake contained high concentration of microcystin and through bioaccumulation exceeded the World Health Organization (WHO) safe level for human consumption. Clean freshwater is undeniably important for human and wildlife survival. These organisms, particularly humans, continually demand and prefer the highest quality water, especially for drinking, food production, and recreational uses (WHO, 2008). Population densities of both aquatic and terrestrial organisms can be greatly influenced by the quality of freshwaters. Frequent and prolonged thunderstorms carry contaminants and potentially degrade many bodies of freshwater (Neal and Acholonu, 2002, www.watershedcouncil.org/learn/water%20terminology/). Pollutants also enter freshwaters through sewage discharges from recreational and commercial boats, industrial effluents, point source runoffs, and underground drainage. Profound water quality skepticisms and anxieties run very deep in agricultural regions, where application of fertilizers and pesticides may be rampant or misused. The Mississippi Department of Environmental Quality (MSDEQ) periodically monitors major freshwater resources in the state for safety. Part of the profound water quality skepticisms and anxieties revolves around human health and wildlife health, given that contaminated water serves as a mechanism to transmit communicable diseases such as diarrhea, cholera, dysentery, typhoid and guinea worm infection (WHO, 2013). Assurance of drinking-water safety consequently is the bed rock for prevention and control of waterborne diseases (www.who.int/water_sanitation_health/dwq/guidelines/en/). As reported by Anderson (2008) and at https://www.whoi.edu/redtide/impacts/freshwater, blooms of cyanobacteria have become more prevalent in the U.S. and globally in the recent decades, as well as the impacts of HABs (http://sb.cc.stonybrook.edu/news/general/022211AlgalBlooms.php). Ikenga (2009 and 2014) found *phosphate, silica, sulfide, and coliform bacteria* in five, small freshwaters regularly used in MS delta for flood, fishing and recreational activities. Although it is not uncommon for HABs, cyanobacteria, and coliform bacteria to surge following influxes of nutrients from the environment; it remains to be determined if the finding of HABs, microcystin, and coliform bacteria in the four freshwaters is a one-time event, biennial or perennial. We conducted this research to generate data that will help understand the predicaments, if any, impacting the four major freshwater in Mississippi, as well as help elucidate the degree of health hazardousness, if any, for humans, birds, and wildlife that use the freshwaters.

2.0 Research Objectives

The first objective of this research was to conduct qualitative assessment of 10 water quality parameters (ammonia nitrogen, chlorine, chromium, copper, cyanide, iron, nitrate, phosphate, silica, and sulfide) for LG, LE, LS, and RB. These 10 water quality parameters, also called chemical nutrients, their physical properties, among other factors are used to determine the health of aquatic ecosystems. The second objective was to quantitatively document five in-situ water quality parameters (dissolved oxygen, pH, temperature, total dissolved solids and salinity). The third was to qualitatively test the water samples for coliform bacteria. The fourth objective was to compare the results of in-situ quantitative measurements of this research to those found by Dash *et al.* (2012) and to determine if any of the chemical nutrients found is presenting a potential health risks for humans, birds and wildlife that use the water resources.

3.0 Study Sites

The four freshwaters of study in this research are the four major freshwater resources in Mississippi after Pickwick Lake (https://www.lakesonline.com/usa/mississippi). Each freshwater of study was primarily engineered to alleviate severe local flood devastations. Three miles Northeast of the city of

Grenada at coordinates 33.8194^{0} N, 89.7736^{o} W is Lake Grenada, which is on the Yalobusha River. Lake Grenada has a surface area of 141.6 km^{2}. At coordinates 34.1489^{o} N, 89.9061^{o} W is Lake Enid with a surface area of 60.7 km^{2}. On the Tallahatchie River in North Mississippi, at coordinates 34.4089^{o} N, 89.7958^{o} W, is Lake Sardis with a surface area of 398.7 km^{2}. The Ross Barnett Reservoir at coordinates 32.4571^{o} N, 90.0179^{o} W has a surface area of 83.7 km^{2}.

Figure 1: Lake Grenada Showing Research Sampling Sites.

Figure 2: Lake Enid Showing Research Sampling Sites.

Figure 3: Lake Sardis Showing Research Sampling Sites.

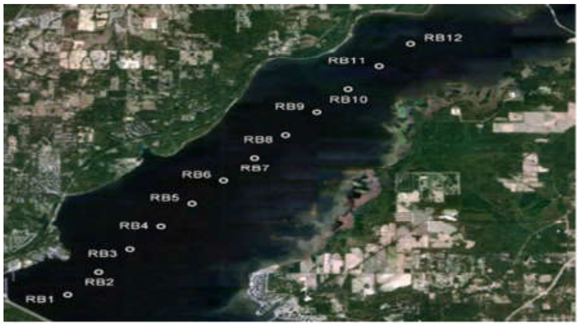

Figure 4: Ross Barnett Reservoir Showing Research Sampling Sites.

4. 0 Materials and Methods

This research began on June 01, 2013 and ended on August 01, 2013. Field trips to LG, LE, LS, and the RB commenced the first week of June, 2013. First we established 12 sampling sites (Figures 1 to 4) by selecting coordinates that provided a good sampling transect of each freshwater of study. All field trips were made per Weather Advisory; on the day most favorable for safe boating. At each sampling site of the freshwaters (Figures 1 to 4), 300 ml of water sample was collected in clean, two Nalgene bottles at depth of one to five meters; using a LaMotte™ water sampler lowered from a motorboat, and a mobile GPS for site location. Overfilled Nalgene bottles were tightly capped, labelled and chilled in ice chests and subsequently transported to the Mississippi Valley State University (MVSU) Water Quality Laboratory. All data generated in this study were tabulated and analyzed to help ascertain the health predicament, if any, impacting the four major freshwaters in Mississippi. The qualitative chemical testing and analyses of 10 water quality parameters: ammonia nitrogen, chlorine, chromium, copper, cyanide, iron, nitrate, phosphate, silica, and sulfide were conducted per manufacturer's specifications, using the Lab-Aid Qualitative Water Pollution Kit (Carolina Biological Supply Co., Burlington, NC). Coliform bacteria test was conducted on all water samples collected using the LaMotte™ Coliform Bacteria Test Kit, per the manufacturer's specifications (Carolina Biological Supply Co., Burlington, NC). In-situ quantitative measurements for temperature, dissolved oxygen (DO), total dissolved solids (TDS), pH, and salinity were also made at each sampling site of the freshwaters, using a Hanna 9828 Multiparameter meter and Probes® (Hanna Instrument, RI). In-situ mean data were generated and statistically compared to those recorded by Dash *et al*., (2012). All water samples were kept cold in a refrigerator until all testing and analyses were promptly completed.

5.0 Results

Qualitative analyses for this study found traces of Iron in LG at sites 1, 2, 7, and the dock area, as well as sites 7 and 12 of LE, and site 1 of RB (Tables 1, 2, and 4). Traces of ammonia nitrogen were found in water from all sampling sites at LE and LS (Tables 2 and 3). All tested sites at RB (Table 4) showed traces of Chlorine, including sites 10 to12 of LS (Table 3). Phosphorous was found in LE at site 12 (Table 2) and also present in traces at all other sampling sites at LE, including the dock area, except site 6. Silica was positive at sites 2 and 12 of LE, sites 5 to 11 and the dock area of LS, as well as site 2 of LG. Traces of Silica were found at sites 1, 7, and the dock area of LG, including all the sampling sites at RB, except site 4. Traces of silica were present at sites 1, 3 to 11 and the dock area of LE, as well as sites 1 to 4 and 12 of LS. Coliform bacteria were detected at all sampling sites (Table 5) at LE and LS, except at their sites 12. LG also tested positive for coliform bacteria at sites 1, 2, 7, and the dock area (Table 5), while RB was coliform bacteria positive at sites 3, 5, 7, and 9 (Table 5). Copper, cyanide, chromium, nitrate nitrogen and sulfide were not detected in any of the freshwater. Table 6 shows the quantitative in-situ measurements from sites 1-12 of each of the freshwaters. In 2012, the mean quantitative measurements found by Dash *et al.*, (2012) at the four freshwaters ranged from 28.86 to 31.44°C for temperature, 7.71 to 9.35 for pH, 5.53 to 9.34 ppm for DO, 37.17 to 44.83 ppm for TDS, and 0.03 to 0.042 ppm for salinity. In 2013, the five water parameter mean measurements recorded ranged from 25.65 to 29.89°C for temperature, 6.76 to 7.79 for pH, 5.53 to 8.09 ppm for DO, 21.58 to 34.75 ppm for TDS, and 0.019 to 0.039 ppm for salinity (Table 7). Temperature,

Table 1: Water Quality Parameters for Lake Granada taken at sites 1-12 on June 04, 2013.

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	DA
NH_4-nitrogen	-	-	-	-	-	-	-	-		-	-	-	-
Chlorine	-	-					-					-	-
Copper	-	-					-					-	-
Chromium	-	-					-					-	-
Cyanide	-	-					-					-	-
Iron	Tr	-					Tr					-	Tr
NO_3 Nitrogen	-	-					-					-	-
Phosphorous	-	-	-	-	-	-	-	-	-	-	-	-	
Silica	Tr	+	-	-	-	-	Tr	-		-	-	-	Tr
Sulfide	-	-	-	-	-	-	-	-	-	-	-	-	-

DA, the dock area; Tr, trace amount; S, water sampling site; +, present in more than trace amount; and -, negative.

Table 2: Water Quality Parameters for Lake Enid taken at sites 1-12 on June 11, 2013.

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	DA
NH_4-nitrogen	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Chlorine	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromium	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide	-	-			-		-					-	
Iron	Tr	-	-	-	-	-	Tr	-	-	-	-	Tr	-
NO_3 Nitrogen	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorous	Tr	Tr	Tr	Tr	Tr	-	Tr	Tr	Tr	Tr	Tr	+	Tr
Silica	Tr	+	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	+	Tr
Sulfide	-	-	-	-	-	-	-	-	-	-	-	-	-

DA, the dock area; Tr, trace amount; S, water sampling site; +, present in more than trace amount; and -, negative.

Table 3: Water Quality Parameters for Lake Sardis taken at sites 1-12 on June 18, 2013.

Parameters	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**DA**
NH_4-nitrogen	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Chlorine	-	-	-	-	-	-	-	-	-	Tr	Tr	Tr	-
Copper	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromium	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide	-	-					-						
Iron	-	-	-	-	-	-	-	-	-	-	-	-	-
NO_3 Nitrogen	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorous	-	-	-	-	-	-	-	-	-	-	-	-	Tr
Silica	Tr	Tr	Tr	Tr	+	+	+	+	+	+	+	Tr	+
Sulfide	-	-	-	-	-	-	-	-	-	-	-	-	-

DA, the dock area; Tr, trace amount; S, water sampling site; +, present in more than trace amount; and -, negative.

Table 4: Water Quality Parameters for Ross Barnett Reservoir taken at sites 1-12 on July 10, 2013.

Parameters	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**DA**
NH_4-nitrogen	Tr	-	-	NA	-	-	-	-	-	-	-	-	-
Chlorine	Tr	Tr	Tr	NA	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Copper	-	-	-	NA	-	-	-	-	-	-	-	-	-
Chromium	-	-	-	NA	-	-	-	-	-	-	-	-	-
Cyanide	-	-		NA			-						
Iron	Tr	-	-	NA	-	-	-	-	-	-	-	-	-
NO_3 Nitrogen	-	-	-	NA	-	-	-	-	-	-	-	-	-
Phosphorous	-	-	-	NA	-	-	-	-	-	-	-	-	-
Silica	Tr	Tr	Tr	NA	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Sulfide	-	-	-	NA	-	-	-	-	-	-	-	-	-

DA, the dock area; Tr, trace amount; S, water sampling site; +, present in more than trace amount; -, negative, and NA, sample not available.

Table 5: Coliform Bacteria Detection at sites 1-12 taken between June 04 and July 10, 2013.

Parameters	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**DA**
Lake Grenada	+	+	-	-	-	-	+	-	-	-	-	-	+
Lake Enid	+	+	+	+	+	+	+	+	+	+	+	-	+
Lake Sardis	+	+	+	+	+	+	+	+	+	+	+	-	+
Ross B. Reservoir	-	-	+	-	+	-	+	-	+	-	-	-	-

DA, the dock area; S, water sampling site; +, positive; and -, negative.

pH, TDS, and salinity were overall a little higher in 2012 than in 2013 (Figure 5). Mean DO measurements however were higher in 2013 for LG and LS (Table 7).

6.0 Discussion

Environmental pollution remains the number one health challenge for freshwater resources. We evaluated 10 qualitative freshwater parameters (ammonia nitrogen, chlorine, chromium, copper, cyanide, iron, nitrate, phosphate, silica, and sulfide) to help diagnose the current health of LG, LE, LS, and RB and to help determine if any health perturbation is in progress that may impact human and wildlife health. All the 10 freshwater parameters evaluated except chromium and cyanide serve also as nutrients for freshwater ecology (www.fosc.org/WQData/WQParameters.htm). These same freshwater parameters/chemical nutrients including chromium and cyanide, also makeup freshwater pollutants, if their concentrations exceed the maximum contaminant level established by the Environmental Protection Agency (EPA) as safe for humans and other animals (http://water.epa.gov/drink/contaminants/#Microorganisms). When chemical nutrients in water exceed maximum concentration levels (MCL) set by EPA, a potential health risk from ingesting such waters exist (www.water-research.net/index.php/standards/primary-standards, http://water.epa.gov/drink/contaminants/#Microorganisms, www.epa.gov/ace/pdfs/Enviroments-Contaminants-Drinking-Water.pdf). Eutrophic effects are possible where chemical nutrients exceed the MCL. Functions of the nutrients in freshwater ecology are discussed in

Table 6: Quantitaive In-situ Measurements at Sites 1-12 of Lakes Grenada (LG), Enid (LE), Sardis (LS), and Ross Barnett Reservoir (RB) taken between June 04 and July 10, 2013. S, water sampling site.

						Temperature (ºC)						
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
LG	24.48	25.22	25.15	21.19	24.49	25.17	24.72	25	24.61	26.19	30.48	31.04
LE	27.12	26.98	27.62	27.76	27.72	28.27	28.19	28	28.32	28.62	28.66	29.26
LS	27.24	27.25	27.27	27.14	27.53	27.89	27.69	27.89	28.09	28.35	28.45	28.80
RB	29.85	30.34	29.6	29.31	29.71	29.7	29.78	29.75	29.67	30.37	30.02	30.55
						pH						
LG	7.26	7.03	7.3	7.28	7.2	7.27	6.77	6.84	6.95	7.40	7.56	6.80
LE	6.73	7.07	6.88	6.25	6.77	6.82	6.71	6.68	6.76	6.70	6.83	6.95
LS	7.63	7.22	7.09	7.08	7.04	7.32	7.19	7.39	7.2	7.05	7.92	7.04
RB	7.62	7.84	7.73	7.64	7.92	7.72	8.1	8.12	7.57	7.50	7.71	7.97
						Dissolved Oxygen (ppm)						
LG	9.83	8.84	8.48	8.54	8.2	8.04	6.64	6.94	7.8	7.45	8.48	7.80
LE	6.34	6.43	6.66	6.30	6.97	7.05	7.04	7.05	7.08	7.21	7.30	7.83
LS	6.50	6.50	6.48	6.50	6.42	7.21	7.06	7.22	6.64	6.40	5.90	5.97
RB	5.22	5.60	5.63	5.10	5.72	5.67	5.84	5.71	5.34	5.30	5.54	5.65
						Total Dissolved Solids (ppm)						
LG	31	16	34	39	39	39	34	40	28	39	38	40
LE	0	36	28	40	36	35	38	36	36	39	35	31
LS	41	38	41	40	40	40	38	43	43	49	49	55
RB	25	22	22	20	17	21	20	24	25	22	25	16
						Salinity (ppm)						
LG	0.03	0.01	0.03	0.04	0.04	0.03	0.03	0.04	0.02	0.03	0.03	0.04
LE	0	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
LS	0.04	0.03	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.05
RB	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Table 7. Comparison of Mean Quantitative in-situ Measurements of June 04-July 10, 2013 and June 18-29, 2012 (reported by Dash *et al*., 2012).

	Temerature (ºC)		**pH**		**Dissolve O_2 (ppm)**		**Total Dissolved Solid (ppm)**		**Salinity (ppm)**	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
Lake Grenada	28.85	25.65	7.71	7.71	7.28	8.09	44.83	34.75	0.042	0.031
Lake Enid	32.01	28.04	9.35	6.76	9.34	6.94	37.17	32.5	0.033	0.027
Lake Sardis	28.89	26.13	7.75	7.26	5.53	6.57	*	43.08	0.04	0.039
Ross Barnett Reservoir	31.44	29.89	8.88	7.79	6.52	5.53	*	21.58	0.030	0.019

*Data not available.

Ikenga (2014). Five of the 10 freshwater parameters /chemical nutrients (ammonia nitrogen, chlorine, iron, phosphorous, and silica) evaluated were found in this study. Ammonia nitrogen, chlorine, iron and silica were detected at trace amounts at three of the freshwaters of study. At LE and LS (Tables 2 and 3), all sites tested positive with traces of ammonia nitrogen; suggesting non source points, such as agricultural runoffs, wastewater treatment plant effluents, and industrial wastewaters. Ammonia nitrogen is derived when ammonia from decaying plants, fish respiration and excretion dissolves in alkaline water (http//:www.was.org/documents/meetingPresentations/AA2009/AA2009_0822.pdf). Trace of ammonia nitrogen detected at site 1 of RB may represent ionization of ammonia produced locally from decaying organic matter. This scenario can negatively impact freshwater ecology as unionized ammonia is highly toxic and can be disastrous to small fish at concentration as low as 0.002 ppm (www.water-research.net/index.php/ammonia-in-groundwater-runoff-and-streams). Soil chloride minerals and perhaps industrial wastewaters may be sources for the traces of chlorine found in this study (Tables 3 and 4). Chlorine when dissolved in water forms chloride salts which can have corrosive effects on metals. Long term exposure to water with MCL of chlorine causes eye and nose irritation and stomach discomfort (http://www.water.epa.gov/drink/contami

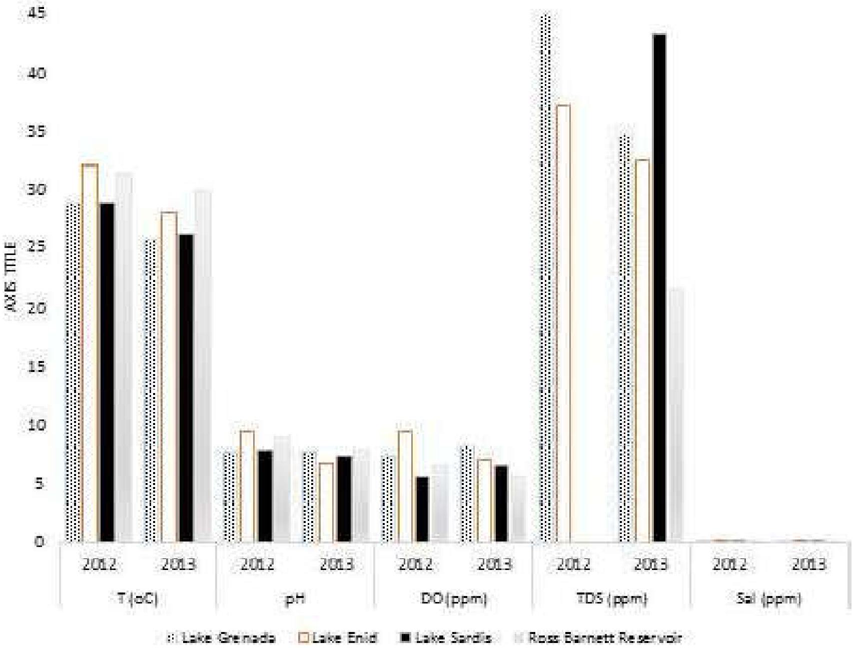

Figure 5: Comparison of In-situ Mean Measurements of Temperature, pH, Dissolved Oxygen, TDS, and Salinity Taken on June 04-July 10, 2013 and June 18-29, 2012. (Data from Dash *et al.,* 2012).

nants/#Microorganisms). Traces of iron detected in this study occur non-pervasively. Such distribution pattern (Tables 3 and 4) seem to implicate multiple point source pollution, such as from anchored fishing boats or from chunks of discarded metal in the water. Traces of iron were found at LE and RB (Tables 3 and 4). Iron is a naturally occurring metallic element of the earth crust. Through weathering of rocks, iron minerals are derived and dissolve as water percolates through soil (Brooker *et al.*, 2015). Silica is one of the most common minerals found naturally as sand or quartz. It is also the most predominant of the five freshwater parameters (chemicals nutrients) found in this study (Tables 1 to 4). Phosphorous was detected only at site 12 of LE and as trace amounts at sites 1to 5, 7 to 11, and the dock area of LE, as well as the dock area of LS. Such distribution pattern suggests some nonpoint sources, which may include agricultural runoffs, phosphorous bedrock, or lawn fertilizers.

The abundance of algal blooms including the HABs, cyanobacteria, and coliform bacteria found by Dash *et al.*, (2012) strongly suggests that active cultural eutrophication (www.water-research.net/index.php/phosphates) must be going on in the four freshwaters. At early stages of cultural eutrophication, large quantities of nutrients (fertilizers) find their way into freshwaters, courtesy of stormwater runoffs. The large amounts of nutrients dumped into freshwaters stimulate eutrophication (Brooker *et al.*, 2015, Cloern, 2013, Campbell *et al.*, 2011), leading to flourishing of phytoplankton, zooplanktons, algae, cyanobacteria and aquatic plants (Neal and Acholonu, 2002, Campbell *et al.*, 2011, and Brooker *et al.*, 2015, www.watershedcouncil.org/learn/water%20terminology/). Rainfalls on the day before field trip could have diluted the nutrient in the freshwaters, resulting in small detectable amounts. It also has been suggested that rapid blooms of phytoplankton, zooplanktons, algae, cyanobacteria and aquatic plants, take up much dissolved nutrients in water as they grow and flourish, leaving very little behind to be detected (www.water-research.net/index.php/phosphates) from subsequent samples of water taken during field trips. In the event of this phenomenon, we suggest periodic monitoring of the low concentration of nutrients, especially when they occur in parallel with blooming of phytoplankton, zooplanktons, cyanobacteria, algae and aquatic plants. The downside of cultural eutrophication are the speed of deterioration of the body of freshwaters; which leads to consumption of more DO at a faster rate; due to biological activities of the flourishing blooms, production of hypoxic waters and loss of species. The increased biomass produced as a result of the flourishing blooms tend to die off faster and takes more time to decompose, thus leading to a large buildup of organic matter at the bottom of freshwaters (Cloern, 2013). A need for regular dredging of the body of water may also occur due to accumulation of decaying extra biomass and the silt brought in by erosions. As organic decomposition continues, the biological oxygen demand will increase causing further depletion of the DO which is essential for supporting a healthy aquatic biota. LS and RB notably recorded low mean DO readings in 2012 and may be under duress. Organisms that keep freshwaters healthy do very poorly in hypoxic waters, if they survive at all. The buildup of dead organic matter plus sediments from erosions and stormwaters also destroy insect spawning habitats, harm fish gills and eggs, as flourishing blooms prevent light from reaching aquatic plants, thereby contributing to a decrease in photosynthesis and further depletion of DO (www.water-research.net/index.php/phosphates and www.water-research.net/index.php/dissolved-oxygen-in-water).

Most of the 12 sampling sites at LE and LS tested positive for Coliform bacteria while four sites were positive at LG and RB (Table 5). Coliform bacteria represent a wide variety of bacteria found in the intestines of many warm-blooded animals, including humans. One of the important groups of the coliform bacteria is the fecal coliform bacteria, which include all the facultative, aerobic, gram-negative rod bacteria that are non-spore forming and can ferment lactose with gas production within 48 h at 35°C (Madigan *et al.*, 2015). Coliform bacteria test is usually the first conducted to test for the presence or of absence pathogenic microbes in freshwaters. The presence of coliform bacteria generally suggests the possibility that other pathogenic microbes, which are also found in fecal matter of humans and other vertebrate organisms may be present (Madigan *et al.*, 2015; http://www.water.epa.gov/drink/contaminants/#Microorganisms). A positive fecal coliform bacteria test is an indicator of freshwater pollution or contamination (Madigan *et al.*, 2015; http://www.water.epa.gov/drink/contaminants/#Microorganisms). Possible sources for these bacteria may be surface runoffs from livestock farms or nonpoint sources of humans and animal wastes. At high counts of fecal coliforms in freshwaters, humans and other animals exposed through ingestion or inhalation of the contaminated water may contract nasopharyngeal infection, dysentery, typhoid fever, hepatitis, etc. (www.water-research.net/index.php/standards/primary-standards).

The quantitative parameters (temperature, pH, DO, TDS, and salinity) measured in this study (Table 6) also constitute the physical (temperature and TDS) and chemical (pH, DO, and salinity) factors that influence the productivity, health and usability of freshwaters. The in-situ measurements taken at each of the 12 sampling sites of the freshwater of study, revealed a non-uniform result with wide ranges for each of the five quantitative parameters (Table 6). This suggests that each of the sampling sites is not equally affected by the prevailing physical and chemical factors. The observed differences in temperature between sampling sites of the freshwaters of study may be related to water flow rate, local wind, and solar energy impacting the bodies of water. All efforts were made to synchronize the 2013 field collections with those of 2012, as much as the Weather Advisory for safe boating permitted. Temperature, pH, DO, and TDS have a major influence on freshwater ecosystems, including their bio-chemical activities, and DO. Generally, warm water contains less DO than cold water of the same volume. In 2013, RB has the highest recorded mean temperature and corollary the least mean DO. LG in the same year was the coldest of the freshwaters of study and corollary has the highest mean DO. In 2012, LE had the highest recorded mean temperature and DO. The misalignment of mean DO here may be due to the highest mean pH and a low mean TDS that were also impacting LE at the time of sampling. Also in 2012, LS has the lowest mean DO suggesting a high demand for oxygen by its resident organisms. TDS data for LS and RB are unavailable for 2012. All the freshwaters of study tested more alkaline or slightly alkaline in 2012 than in 2013, except for LE that tested slightly acidic in 2013. Likewise the mean salinity concentration was higher in 2012 than in 2013. These differences may be attributed to different physical locations, weather, and surrounding urban activities that regularly influence each of the freshwaters.

7.0 Conclusion

This research found five of the 10 water quality parameters (chemical nutrients) in the freshwaters studied. It is not clear to what extent rainfalls on the day before field trip or rapid absorption of chemical nutrients by flourishing blooms of phytoplankton, zooplanktons, algae, cyanobacteria and aquatic plants impacted nutrients presence in the waters. The 2013 averages for temperature, pH, DO, TDS, and salinity are similar to those recorded by Dash *et al.*, (2012). We contend that the abundance of algal blooms reported by Dash *et al.*, (2012) for the four freshwaters is likely to be the same or similar for 2013 and that phosphorous and ammonia nitrogen may be the chemical nutrients stimulating the expected eutrophication for 2013. Coliform bacteria test suggests the possibility that other pathogenic microbes may be present in all the four freshwaters. Humans, birds and wildlife therefore, could potentially get sick if they drink from the waters. We recommend additional studies to monitor the freshwaters for pathogenic *E. coli*, as well as to determine the concentrations of the five chemicals found by this study, and how often they impact the freshwaters.

References

Anderson, D. M., Burkholder, J. M. Cochlan, W. P., Gilbert, P. M., Gobler, C. J., Heil, C. A., Kudela, R. M., Parsons, M. L., Rensel, J. E. J., Townsend, D. W., Trainer, V. L. and Vargo, G. A. 2008, "Harmful algal blooms and eutrophication: Examining linkages from selected coastal regions of the United States", Harmful Algae **8,** 39– 53.

Brooker, Robert J., Widmaier, Eric P., Graham, Linda E., and Peter D. Stiling. 2015. Biology, 3rd ed., McGraw-Hill Higher Education, Dubuque, IA., 1263pp.

Carmichael, W.W. 1997, "The cyanotoxins", In: Callow, J. (Ed.), Advances in Botanical Research, vol. 27. Academic Press, London, 211–256.

Campbell, N. A., J. B. Reece, L. A. Urry, M. I. Cain, S. A. Wasserman, P. V. Minorsky, and R.B. Jackson. 2011. Biology, 11th ed., Benjamin Cummings, NY, 1267pp.

Cloern, J. 2013, Eutrophication. Retrieved on May 17, 2015 from www.eoearth.org/view/articles/152690/

Codd, G.A., Bell, S.G., Kaya, K., Ward, C.J., Beattie, K.A. and Metcalf, J.S. 1999, "Cyanobacterial toxins, exposure routes and human health", Eur. J. Phycol. **34(4),** 405– 415.

Dash, Padmanava, Wellington Ayensu, Julius Ikenga, James Pickney 2012, Field Trips to Lakes Grenada, Enid, Sardis and Ross Barnett Reservoir. Research Notes.

Falconer, I. R, and A. R. Humpage 2005, "Health risk assessment of cyanobacterial (bluegreen algal) toxins in drinking water", *Int. J. Environ. Res. Public Health* **2(1),** 43–50.

Garcia, A. C., Bargu, S., Dash, P., Rabalais, N. N., Sutor, M., Morrison, W. and Walker, N. D. 2010, "Evaluating the potential risk of microcystins to blue crab (*Callinectes sapidus*) fisheries and human health in a eutrophic estuary", *Harmful Algae* **9,** 134–143.

http://sb.cc.stonybrook.edu/news/general/022211AlgalBlooms.php

http//:www.was.org/documents/meetingPresentations/AA2009/AA2009_0822.pdf

http://water.epa.gov/drink/contaminants/#Microorganisms Assessed on May 24, 2015.

http://www.was.org/documents/meetingPresentations/AA2009/AA2009_0822.pdf

www.water-research.net/index.php/standards/primary-standards

https://www.whoi.edu/redtide/impacts/wildlife/birds

https://www.whoi.edu/redtide/impacts/freshwater

Ikenga, Julius O. and Richard Wagner 2005, "Comparison of Ecto-parasites and Endo-parasites of *Lepomis marchirus* and *Pomoxis annulatus* Inhabiting a Carroll Co. MS Watershed Pond", Abstract, J. Miss. Acad. of Sci. **50(1),** p.119.

Ikenga, Julius O. 2009, "Quality of Fresh Water Resources at Five Locations in the Mississippi Delta", Abstract, J. Miss. Acad. of Sci. **54(1),** 117-118.

Ikenga, Julius O. 2014, "Freshwater Status in Mississippi Delta, USA", J. Miss. Acad. of Sci., **50(3-4),** 422-427.

Mader, S. Sylvia and Michael Windelspecht 2014, Inquiry into Life. Fourteenth ed., McGraw Hill Publishers, Dubuque, IA, 764pp.

Madigan, T. M, J. M. Martinko, K. S. Bender, D. H. Buckley, and D. A. Stahl. 2015. Brock Biology of Microorganisms, 14th edition. Pearson Publishing, NY, p. 906-922.

Metcalf, J. S. and G. A. Codd 2004, Cyanobacterial Toxins in the Water Environment. ROCK Reviews of Current Knowledge, Marlow, Bucks, UK: Foundation for Water Research.

Mishra, R. Deepak, Sachidananda Mishra, and Sunil Narumalani (2014). Hyerspectral remote sensing of Cyanobacteria: successes and challenges. Retrieved from http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=1939146

Neal, O. Chadric and Alex D. W. Acholonu 2002, "A Comparative Study of the Seasonal Distribution of Pollutants in Eagle Lake and Chotard Lake in Warren County, MS", J. Miss. Acad. of Sci. **47(1),** p.88.

WHO (2008). Water Sanitation and Health. World Health Organization (available at http://www.who.int/water sanitation health/publications/facts2004/en/index.html)

WHO (2013). Water Quality and Health Strategy 2013-2020 (available at http://www.who.int/water_sanitation_health/publications/2013/water_quality_strategy/en

www.epa.gov/ace/pdfs/Environments-Contaminats-Drinking-Water.pdf

www.fosc.org/WQData/WQParameters.htm

www.water-research.net/index.php/phosphates

www.water-research.net/index.php/ammonia-in-groundwater-runoff-and-streams

www.water-research.net/index.php/dissolved-oxygen-in-water

www.water-research.net/index.php/standards/primary-standards

www.watershedcouncil.org/learn/water%20terminology/

www.who.int/water_sanitation_health/dwq/guidelines/en/

Acknowledgements

This research was funded by the USDA Title 111, Faculty Development Program, Mississippi Valley State University, Itta Bena, MS, USA and by support from Mississippi INBRE, funded by an Institutional Development Award (IDeA) from the National Institute of General Medical Sciences of the National Institutes of Health under grant number P20GM103476. We thank Dr. Raymond Williams for statistical analysis suggestion.