Available online at www.elixirpublishers.com (Elixir International Journal)

Aquaculture

Elixir Aquaculture 124 (2018) 52106-52113

ISSN: 2229-712X

Water Quality of the Ashaiman Reservoir and Fish culture Facilities at The Aquaculture Demonstration Centre in Ashaiman, Ghana.

Samuel Addo and Pamela Afi Tettey
Department of Marine and Fisheries, Science University of Ghana.

ARTICLE INFO

Article history:
Received: 14 September 2018;
Received in revised form:
25 October 2018;
Accepted: 5 November 2018;

Keywords
Water Quality,
Water Quality Index (WQI).

ABSTRACT

This study evaluated water quality of the Ashaiman reservoir and fish holding facilities at a hatchery close to the reservoir. Physicochemical parameters, nutrients, productivity and fish pathogenic bacteria were determined monthly. Physicochemical parameters at all sites were within suitable range for fish production. Nutrient levels were however significantly higher in the culture facilities than the reservoir ($P<0.05$). Productivity levels and pathogens were above the suitable limit in hatchery tanks but within acceptable range in the reservoir. A water quality index (WQI) of 100.01 for the reservoir is indicative of poor quality. Pathogenic bacteria load was high and should be of concern to the fish hatchery operations.

Introduction

Due to the increased necessity for food production, the aquaculture industry is growing rapidly, and fish represents an important source of protein and essential nutrients for human health (Gobi *et al.*, 2016). Aquaculture could be integrated into reservoir fisheries. Reservoirs have been used to provide a store of water for agriculture including aquaculture, industrial and household purposes for thousands of years and also for flood control. As a result, there have been many concerns to protect reservoirs to ensure posterity benefits from their functions.

Within the growing aquaculture industry, it is conventional that water of good quality be supplied for viable aquaculture production since poor water quality can result in low profit, low product quality and potential human health risks. Additionally, production is reduced when the water contains high concentrations of disease causing microbes that can impair development, growth, reproduction, or even cause mortality to the cultured species. Water quality assessment therefore, borders on the measurement and monitoring of water variables such as transparency, pH, conductivity, temperature, nutrients including phosphates and nitrates, and pathogenic bacteria.

Bacterial diseases are among the most important causes of losses among fish stocks (Inglis *et al.*, 1993). Among the etiological agents of bacterial fish diseases, *Pseudomonas* and *Aeromonas* are considered to be two of the most important fish pathogens which are also human pathogenic bacteria from aquatic environment. However, these species have received little attention, although they are responsible for ulcer type diseases including ulcerative syndrome, bacteria hemorrhagic septicemia, tail and fin rot, bacterial gill rot and dropsy in fish species, usually resulting in economic losses (Gobi *et al.*, 2016).

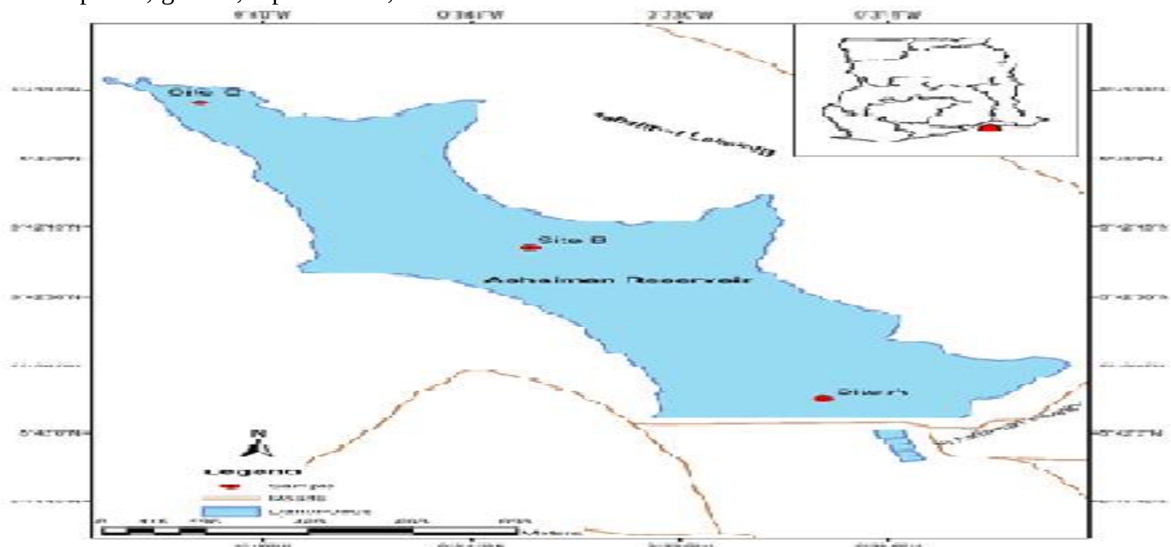

Fig.1. A Map of Ghana Showing the Ashaiman Reservoir and Sampling Sites.

Tele:
E-mail address: pamelatettey.pt@gmail.com

Plate 1. Aerial view of the Aquaculture Demonstration Centre, Ashaiman.

In view of this, this work was aimed at evaluating the physico-chemical and biological parameters and estimating the water quality index (WQI) of the Ashaiman Reservoir and some fish holding facilities at the Centre.

Materials and methods

Study Area

The study was carried out in Ashaiman Reservoir (Fig. 1) and Aquaculture Demonstration Centre in Ashaiman (Greater Accra Region) of Ghana.. The Center (Plate 1) is enclosed between Longitude N 05.669 77 ♂ and Latitude W 000.05 394 and was set up 44years ago. The main activities of the Aquaculture Demonstration Center are to produce tilapia and catfish fingerlings to out-grower fish farmers throughout the country and beyond to increase aquaculture production (Ghana Statistical Service, 2014).

Methodology

A reconnaissance survey was conducted in December where pictures were taken with a DJI Phantom 3 Professional Unmanned Aerial Vehicle. Sampling was done on monthly basis from January to March, 2017. Samples were collected from three sites on the reservoir, the Pilot Aquaculture Centre and a canal leading to the centre from the reservoir. Following guidelines stated in APHA (2012), measurements and analysis were made on physico-chemical parameters including phosphate, alkalinity, ammonia, nitrate, temperature, conductivity, pH, salinity and Dissolved Oxygen (DO). In situ measurement was done for water temperature, pH, conductivity, salinity and DO using a hand-held OAKTON PCD 650 multi-parameter probe (HANNA HI 9828, Hanna Instruments, United Kingdom) according to the Standard Methods for the Examination of Water and Wastewater APHA (2012).

Samples for nutrient analysis were collected using pretreated high-density plastic bottles (500 ml) equipped with screw caps. These were immersed gently to at least 20 cm below the surface of the water to rinse them with the water thrice and then filled to the brim in an oblique manner. These bottles were stored on ice in an iced chest and transported to the laboratory. Sampling for Chlorophyll-a analysis was achieved using sterilized (1.5 L) bottles. The bottles were lowered gently to about 20 cm below the surface of the water. For microbial sampling, sterilized and sealed bottles (500 ml) obtained from Water Research Institute (WRI) of the Centre for Scientific and Industrial Research (CSIR) were gently immersed to 20 cm below the surface of the water (Plate 3 and 4). Samples for microbiological analysis were taken to the Microbiology Laboratory at WRI within four hours of collection.

Nutrient analysis in the laboratory was done within a 24-hour period after collection of samples to avoid further degeneration of nutrients by bacteria and phytoplankton. The samples were allowed to thaw to room temperature and analysis was done using the HACH DR2800 Spectrophotometer following APHA (2012) procedures. Reagent blanks were made by treating an aliquot of distilled water as a sample and carrying out the full analysis. In cell blank assessment, the spectrophotometer cells were filled with distilled water and measurement taken to find the difference between sample and reference cells. Throughout the measurement and analyses of water samples, care was taken not to contaminate glassware by rinsing bottles, vials, pipettes, and other such shared instruments. For Microbiological analysis, water samples taken to WRI were immediately analyzed to ensure accuracy

Microbial Analysis

For microbiological analysis, 100 mL of the samples were filtered through 0.04 μm pore-sized filter (cellulose nitrate membranes, Whatman Laboratory Division, Maidstone, England) using a water pump (model Sartorius 16824) of a membrane filtration system in a laminar flow hood. These membranes were picked with a pair of forceps and aseptically placed up on plates with appropriate selective media ensuring that no air bubbles were trapped. at 37°C for 24 hours. All the media were prepared according to the manufacturers' instructions (Biolab, Merck, South Africa). The plates were incubated at 37°C for 24 hours using a Fisher Brand Shel Lab General Purpose Incubator (Biolab, Merck, South Africa). The colonies on the plates were enumerated, characterized, and recorded after the 24 hours using a Stuart Biocote colony counter. Centrimide Agar was used for the selective isolation of Pseudomonas bacteria whiles Aeromonas Agar was used for the selective differential isolation of Aeromonas bacteria. The results were expressed as the number of Pseudomonas and Aeromonas in 100 ml of water. The analysis was in accordance with Standard Methods for the examination of water and wastewater APHA (2012).

Data Analysis

Bar display charts showing variation from averaged values were used to represent measurements of both *in situ* and laboratory analyses of samples using Microsoft Office Excel 2016. The Microsoft Office Excel 2016 spreadsheet was used to organize the data into tables out of which graphs were generated as pictorial representation of the data based on values obtained. Microcal Origin version 6.0, a statistical tool, was used to run a one-way Analysis of Variance (ANOVA) of the data significant differences between the means. The means were compared using Tukey's HSD Test. The level of significance of 5% was adopted in all statistical analyses. For the purpose of analysis the sites in the reservoir were taken as one entity, the canal as another, and the ponds as one and the tank as one.

Results

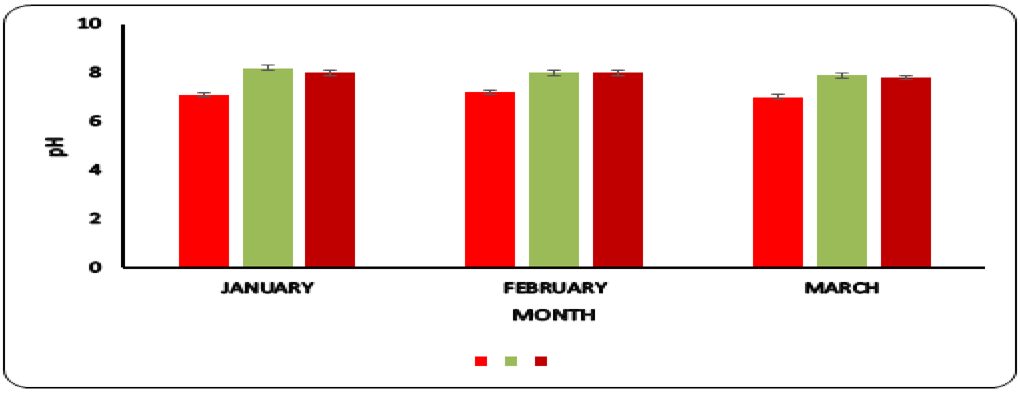

Fig 2. Monthly mean variation in pH at the different sites. Error bars indicate standard deviations.

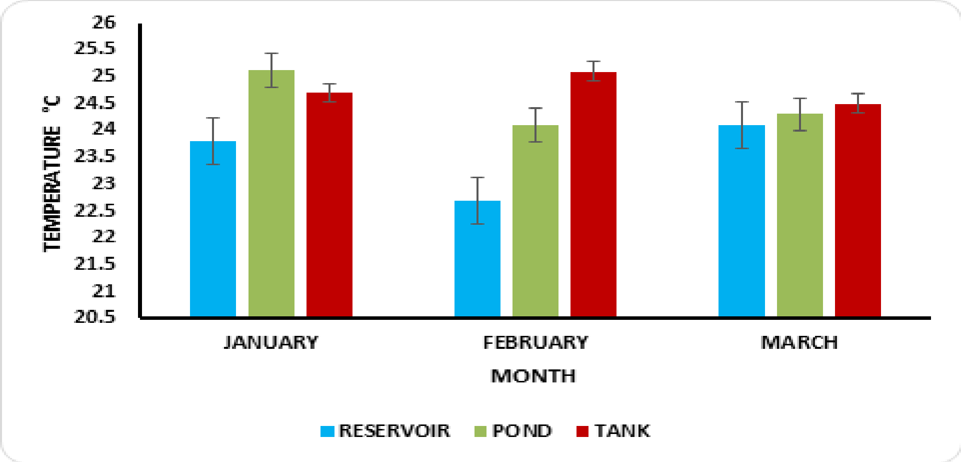

Fig 3. Monthly mean variation in temperature at the different sites. Error bars indicate standard deviations.

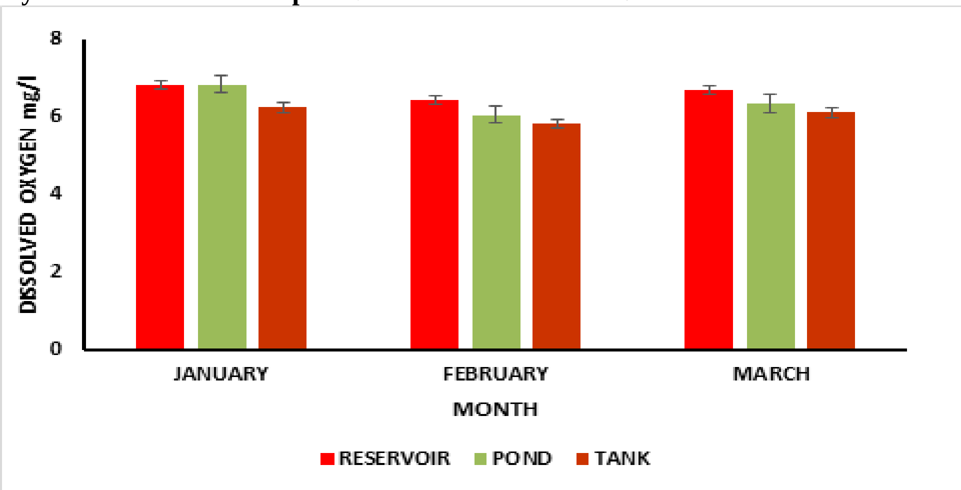

Fig 4. Monthly mean variation in dissolved oxygen at the different sites. Error bars indicate standard deviations.

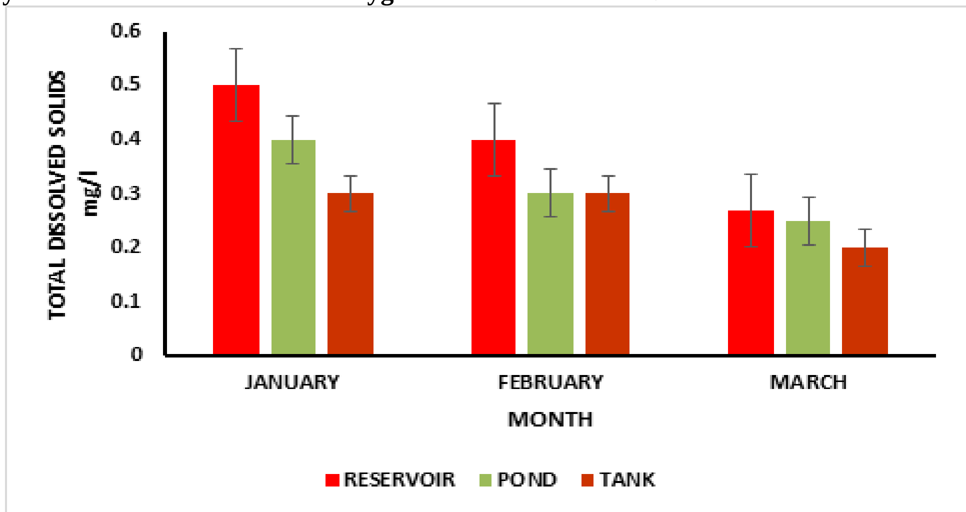

Fig 5. Monthly mean variation in total dissolved oxygen at the different sites. Error bars indicate standard deviations.

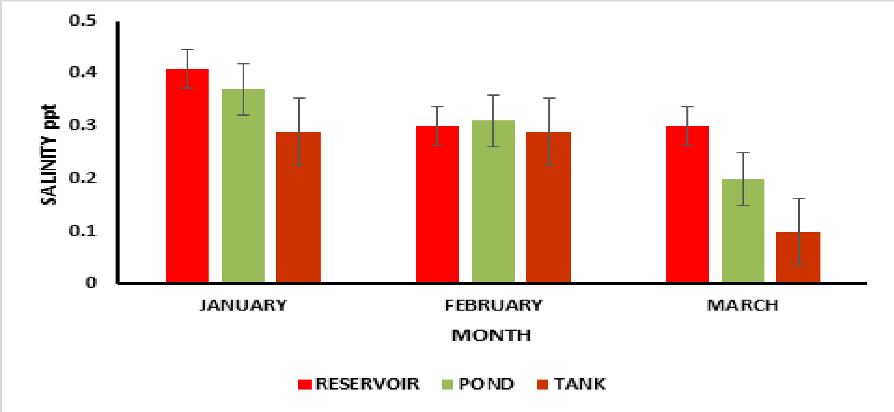

Fig 6. Monthly mean variation in salinity at the different sites. Error bars indicate standard deviations.

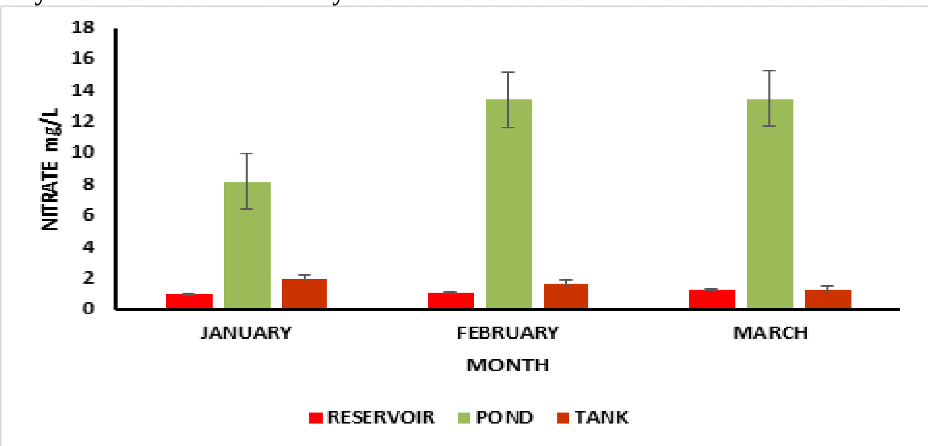

Fig 7. Monthly mean variation in nitrate at the different sites. Error bars indicate standard deviations.

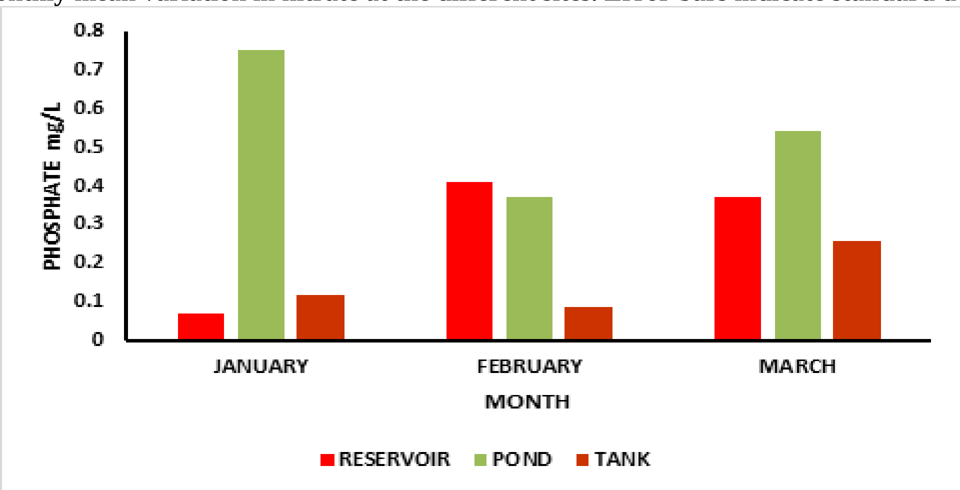

Fig 8. Monthly mean variation in phosphate at the different sites. Error bars indicate standard deviations.

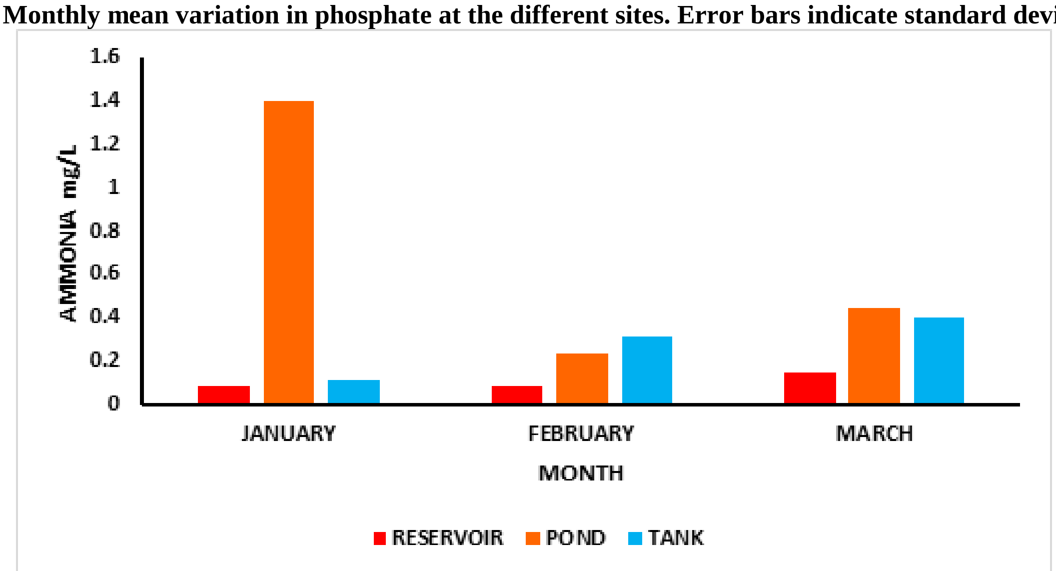

Fig 9. Monthly mean variation in ammonia at the different sites. Error bars indicate standard deviations.

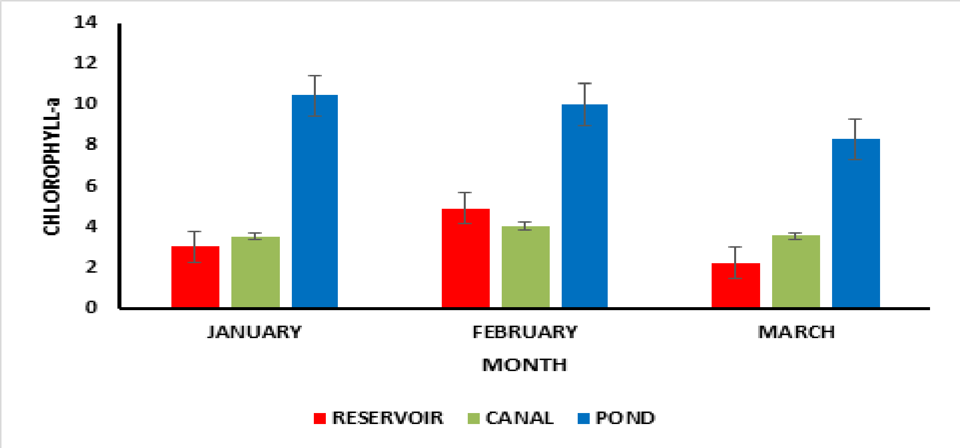

Fig 10. Monthly mean variation in Chlorophyll-a at the different sites. Error bars indicate standard deviations.

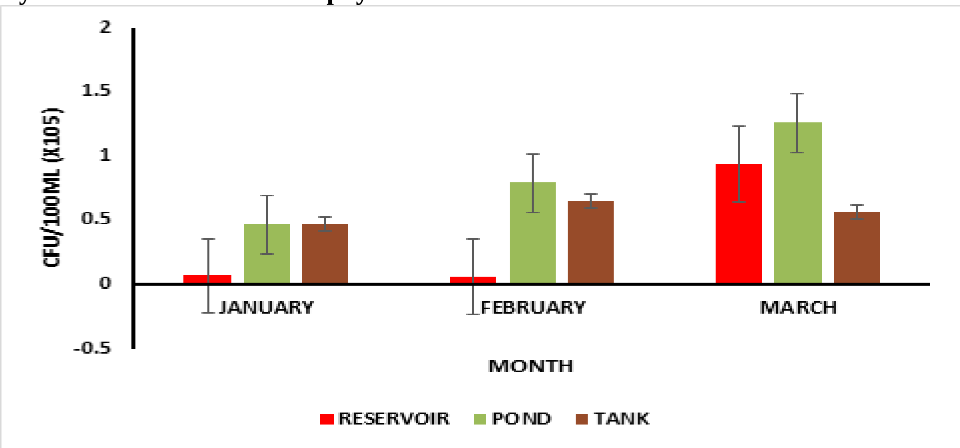

Fig 11. Monthly mean variation in *Aeromonas* sp. at the different sites. Error bars indicate standard deviations.

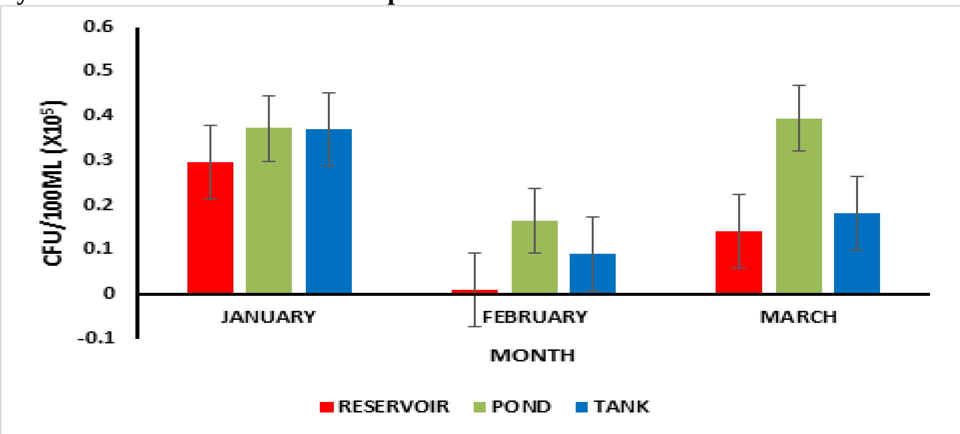

Fig 12. Monthly mean variation in Pseudomonas sp. at the different sites. Error bars indicate standard deviation.

Assessment of water quality standard from water quality index (WQI)

In order to ascertain the level of quality of the Ashaiman Reservoir, a water quality index was developed using their corresponding physico-chemical and biological parameters as described by Ramakrishnaiah *et al.* (2009).

Discussion

Dissolved oxygen in water is of prime importance for maintenance of aquatic life. It reflects the physical and biological processes prevailing in the waters (Solanki *et al.*, 2007). The reservoir had higher dissolved oxygen levels as compared to the culture facilities. This could be attributed to the fact that the reservoir had a larger surface area as compared to the culture facilities (pond and tank), as a result, flushing in the reservoir may be higher as compared to the tank and pond. Also, decomposition of unutilized feed introduced into the pond and tank could have also accounted for the low levels of dissolved oxygen recorded in the culture facilities.

Temperature obtained during this study fell generally within the range (22.7- 25.1 °C), which according to (Tessema *et al.*,2014) is suitable for tropical fish production. However, the highest temperatures were recorded in the ponds and tanks (25.12 and 25.1) respectively, which could be attributed to low water level and high air temperature (Thirupathaiah *et al*.,2012).

The pH limit for protection of aquatic life is 6.0 to 8.5 (ISI, 1974). However, Tessema *et al.* (2014), stated that the desirable range of pH for tropical fish is 6.5-9 and all the values recorded for the reservoir and the culture facilities fell within this pH range. With means varying between a moderately low value of 7.0 in the reservoir to a slightly higher value of 8.9 in the culture facilities, the slight increase in pH in the culture facilities may be due to the occurrence of high photosynthetic activity and decomposition of autochthonous matter which increases the nutrient concentration at higher temperature.

Total dissolved solids represent total mineral contents, which may or may not be toxic. A range of 0.2- 0.5ppt (200-500mg/l) was recorded for all stations which fell within the permissible limit of 500 mg/L set by the USA Environmental Protection Agency (Charkhabi and Sakizadeh, 2006). However, the highest TDS value of 0.5ppt, although acceptable, was recorded in the reservoir and this indicate the possible effects of anthropogenic sources along the reservoir, particularly as a result of domestic waste or flood from catchment area (Utang *et al.,* 2012). The low total dissolved solids recorded in the culture facilities may also indicate enough fish diversity (Utang *et al.,* 2012).

Salinity in water is due to the presence of ions such as carbonates and bicarbonates which result in the pollution of water bodies (Kumar, 2014). According to Omoniyi and Agbon (2008), salinity levels for the production of tropical fish should be less than 10ppt. Salinity levels recorded during the study were suitable for the survival of tropical fish species. The high salinity levels in the reservoir as compared to the fish culture facilities could be due to the high rate of evaporation in the reservoir. In the ponds however, regular addition of water in the ponds and tanks keeps the volume of water diluted hence salinity levels low.

Thirupathaiah *et al*. (2012) indicated that ammonia and nitrate levels lower than 0.20 mg/l and 10mg/l respectively are suitable for the growth of tropical fish as they will not have any adverse effect on fish growth. These ranges were exceeded only in the pond (1.2-1.4mg/l and 8.9-13.45mg/l for ammonia and nitrate). This could probably be due to the high feeding rate of fish that goes on in the ponds.

Phosphate levels in water could serve as an indication of pollution. Phosphate is the major limiting factor in many aquatic ecosystems and is responsible for the growth of both plankton and plants in water which in turn are used by fish as food (Reddy & Parameshwar, 2016). Studies conducted by (Zhou *et al*., 2011) indicated that water with phosphate levels above 0.70 mg/l could have detrimental effects on fish growth as it could lead to reduced levels of dissolved oxygen. An increase in these nutrients beyond suitable levels could result in eutrophication. The high level of phosphate encountered in the ponds therefore gives much room for concern.

The water quality index estimated for the Ashaiman Reservoir during the study period indicates that the reservoir was poor. According to Ramakrishnaiah *et al.* (2009), a waterbody is said to have excellent water quality if it ranges from 0-50, good if it ranges from 50-100, poor from 100-200 and very poor from 200-300.

According to (KDHE, 2011), chlorophyll-a values in reservoirs and water holding facilities for aquaculture should not exceed 10 μg/l. Utilization of water with chlorophyll-a values higher than 10 μg/L for aquaculture can result in harmful algal blooms and anoxic conditions. The tank recorded the highest chlorophyll-a values across the months. This could possibly explain why the tank had the lowest dissolved oxygen levels. Chlorophyll-a helps in photosynthesis giving off oxygen as a by-product. At night when photosynthesis does not occur, these phytoplankton will use up the oxygen thereby lowering the dissolved oxygen levels which could have an adverse effect on the fish.

Bacteria are opportunistic pathogens and may cause mortalities when the fish are under stress (De Sousa & Silva-Souza, 2001). Pseudomonas and Aeromonas are among the major pathogenic bacteria which frequently cause economic losses in aquaculture and are associated with elevated levels of water pollution.

According to Patra *et al*. (2010), introduction of water with Pseudomonas and Aeromonas microbes higher than 1.0 x 103 cfu/100 ml is harmful for aquaculture production. High levels of bacteria in a waterbody may be as a result of biological processes and the introduction of feed and fertilizer. In this study, the high counts of these pathogenic bacteria above 1.0 x 103 cfu/100 ml is a threat to the activities at the Pilot Aquaculture Centre. The fact that these bacteria are of zoonotic essence makes it a threat both to fish and humans. Fish species may harbor these bacteria and the presence of these pathogenic organisms can pose severe health risks to consumers in general and immunocompromised individuals in particular (Mulamattathil *et al.,* 2014).

Conclusion

Physico-chemical parameters obtained from the study were within the acceptable ranges for the survival and sustainability of fisheries. Water received from the reservoir was suitable for aquaculture production though the water quality index indicated that it was polluted with respect to domestic consumption. Nutrient levels obtained at the farm were slightly above the suitable ranges and this is of concern since the Centre produces fingerlings, which are fragile and slight changes in nutrient concentrations could affect their survival.

Acknowledgments

The authors would like to thank Mr. Edmund Datuah, (The Director of Ashaiman Aquaculture Centre), and all the staff of the Ashaiman Aquaculture Centre for their support during the field work and data collection. Many thanks to the Department of Marine and Fisheries Sciences, University of Ghana and the Microbiology laboratory of the Water Research Institute for the use of their facilities.

References

American Public Health Association (APHA), “American Water Works Association (AWWA), and the Water Environmental Federation (WEF)”. Standard Methods for Examinations of Water and Wastewater, 20th ed. United Book Press, Inc. Baltimore, Maryland,1998 .

American Public Health Association (APHA), “Standard methods for the examination of water and wastewater”, 20th ed. Clesceri LS, Greenberg AE, & Eaton, AD, (Eds),1998.

APHA, “Standard methods for the examination of water and waste water; 19th ed. American Water Works Association and Water Pollution Control Federation” Washington, DC, 1995.

American Public Health Association, Washington, DC. APHA, AWWA, WEF. Standard Methods for examination of water and wastewater. 22nd ed. Washington: American Public Health Association; 2012, 1360 pp. ISBN 978-087553-013-0. http://:www.satndardmethods.org/

E. K. Balon and A.G. Coche, “Lake Kariba: A man-made tropical ecosystem in Central Africa”, Eds.The Hague: Dr. W. Junk Publ., 1974, pp. 766

C. E. Boyd, “Water quality in warm water fish ponds”. USA : Craftmaster Printers Inc., 1979, 353.

D. T. Brehan Mohammed & W. Z. Melaku, “Physical , Chemical , Biological properties and fish species type of Geray reservoir” 2010. https://doi.org/10.17352/2455-8400.000012.

S. R. Carpenter, H. S. Emily, and M. J. V. Zanden. "State of the world's freshwater ecosystems: physical, chemical, and biological changes." Annual review of Environment and Resources 36 2011, pp. 75-99.

S. A. Castine, A. D. McKinnon, A. P. Nicholas, A. T. Lindsay, and de N. Rocky, "Wastewater treatment for land-based aquaculture: improvements and value-adding alternatives in model systems from Australia." Aquaculture Environment Interactions 4, 2013, pp. 285-300.

D. V. Chapman, and World Health Organization, "Water quality assessments: a guide to the use of biota, sediments and water in environmental monitoring." UNESCO/WHO/UNEP 1996, 651.

S. L. Dwivedi,, and P. Vandna, "A preliminary assignment of water quality index to Mandakini river, Chitrakoot." Indian Journal of Environmental Protection 27, no. 11, 2007, pp. 1036.

B. N. P. Gagan, "Reservoir Fisheries in Nepal. Status of Reservoir Fisheries in Five Asian Countries Status of Reservoir Fisheries in Five Asian Countries", pp. 113. Retrieved from http://www.iceida.is/media/pdf/reservoir_book_prepress.pdf

GESAMP, "GESAMP Reports and Studies "No. 33, United Nations Educationl, Scientific and Cultural Organization, Paris, Report of the Eighteenth Session, Paris, 1988.

(GIDA), "Ghana Irrigation Development Authority"Annual report of the Upper West Region, 2011.

N. Gobi, R. Chinnu, V. Baskaralingam, M. Balasubramanian, V. Sekar, M. Kadarkarai, and B. Giovanni, "Oreochromis mossambicus diet supplementation with Psidium guajava leaf extracts enhance growth, immune, antioxidant response and resistance to Aeromonas hydrophila." Fish & shellfish immunology 58, 2016, pp.572-583.

C. Gray, "Quality assurance and assessment of scholarly research." Research Information Network 23, 2010.

C. C. Hach, R. D. Vanous, and J. M. Heer, "Understanding Turbidity Measurements: Technical Information Series-Booklet No. 11." Hach Company, Colorado, USA,1985.

H. S. Verfahrenshandbuch, "Hach Company, Loveland, Colorado, USA, 3." 2003.

Y. Hung, K. W. Lawrence, and K. S. Nazih K, "Handbook of environment and waste management: air and water pollution control". Vol. 1, eds, World Scientific, 2012.

V. Inglis, J. R. Ronald, and R. B. Niall, "Bacterial diseases of fish." 1993.

A. M. Kalwale, and A. S. Padmakar, "Determination of physico-chemical parameters of Deoli Bhorus dam water." Advanced Applied Science Research 3, no. 1, 2012, pp. 273-279.

KDHE (Kansas Department of Health and Environment Bureau of Water), "Water Quality Standards White Paper - Chlorophyll-a Criteria for Public Water Supply Lakes or Reservoirs", 2011, 1–11.

S Kumar, DM Lawrence, PA Dirmeyer, J Sheffield Kumar, "Less reliable water availability in the 21st century climate projections." Earth's Future 2, no. 3 ,2014, pp. 152-160.

F. K. Meme, F. O. Arimoro, F. O. Nwadukwe, "Analyses of physical and chemical parameters in surface waters nearby a Cement Factory in North Central, Nigeria." Journal of Environmental Protection 5, no. 10, 2014, pp. 826.

Ministry Of Fisheries and Aquaculture Development, "Fisheries Commission 2015 Annual Progress Report Republic of Ghana: Ministry of Fisheries and Aquaculture Development"' 2015, pp.87.

S. K. Mohanty, "Water Quality Index of four Religious Ponds and its Seasonal Variation in the Temple City, Bhubaneswar." Fundamentals of Limnology, 2005, pp.162.

T. Murdoch, C. Martha, and K. O'Laughlin. "The streamkeeper's field guide: watershed inventory and stream monitoring methods", 1996.

M. K. Mustapha, Assessment of the Water Quality of Oyun Reservoir , Offa , Nigeria , Using Selected Physico-Chemical Parameters, 319, 2008, pp. 309–319.

R. Mylavarapu, Impact of phosphorus on water quality (2008). Retrieved on June 31, 2015 from http://edis.ifas.ufl.edu

S. Patra, T. K. Das, C. G. Subhas, D. Sarkar, and B. B. Jana. "Cadmium tolerance and antibiotic resistance of Pseudomonas sp. isolated from water, sludge and fish raised in wastewater-fed tropical ponds" 2010.

T. Quarcoopome, A. Francis, and P. Ofori-Danson. "Changes in the fish community of the Kpong Headpond, lower Volta River, Ghana after 25 years of impoundment." Revista de biologia tropical 59, no. 4 ,2011, pp.1685-1696.

C. R. Ramakrishnaiah, C. Sadashivaiah, and G. Ranganna. "Assessment of water quality index for the groundwater in Tumkur Taluk, Karnataka State, India." Journal of Chemistry 6, no. 2, 2009, pp. 523-530.

G. D. Roriz, Geórgia Dantas, M. K. de V. C. Delphino, I. A. Gardner, and V. S. P. Gonçalves, "Characterization of tilapia farming in net cages at a tropical reservoir in Brazil." Aquaculture Reports 6, 2017, pp. 43-48.

S. Simões, Fabiano, Altair B. Moreira, M. C. Bisinoti, M. Sonia, G. Nobre, and S. M. Yabe, "Water quality index as a simple indicator of aquaculture effects on aquatic bodies." Ecological indicators 8, no. 5 ,2008, pp. 476-484.

State Water Resources Control Board, "The Clean Water Team Guidance for Watershed Monitoring and Assessment" 2010.Retrieved on March 26, 2015 from http://www.arroyoseco.org/wqparameters.htm

F. Tavares, F. R. Lapolli, R. Roubach, M. K. Jungles, D. M. Fracalossi, and A. M. Moraes. "Use of domestic effluent through duckweeds and red tilapia farming in integrated system." Pan-American Journal of Aquatic Sciences 5, no. 1, 2010, pp.1-10.

A. Tessema, A. Mohammed, T. Birhanu, & T. Nega, "Assessment of Physico-Chemical Water Quality of Bra Dam", 2014.

M. Thirupathaiah, C. H. Samatha, and C. Sammaiah. "Analysis of water quality using physico-chemical parameters in lower manair reservoir of Karimnagar district, Andhra Pradesh." International Journal of Environmental Sciences 3, no. 1, 2012, pp. 172.

P.U. Uzukwu, O. S. George, and N. A. Jamabo. "Aquaculture Engineering: Status and Roles in the Growth of Aquaculture Industry in Nigeria." Current Research Journal of Biological Sciences 2, no. 6 ,2010, pp. 410-413.

G.Vivekanandhan,A.A.M.Hatha,andP.Lakshmanaperumalsamy."PrevalenceofAeromonashydrophila in fish and prawns from the seafood market of Coimbatore, South India." Food Microbiology 22, no. 1,2005, pp. 133-137.

N. Vijayakumar, G. Shanmugavel, D. Sakthivel, and V. Anandan, "Seasonal variations in physico-chemical characteristics of Thengaithittu estuary, Puducherry, South East-CoastofIndia."Adv.Appl.Sci.Res.5,2014,pp.39-49.

World Health Organization, "Guidelines for drinking-water quality":recommendations.Vol.1. World Health Organization, 2004.

R. Wright, Roger, "Seasonal variations in water quality of a West African river (R. Jong in Sierra Leone)." Rev. Hydrobiol. Trop 15, no. 3, 1982, pp. 193-199.

H. Zhou, J. Cui-ling, Z. Li-qin, W. Xin-wei, H. Xiao-qin, C. Jun-yu, and X. Ming-hua. "Impact of pond and fence aquaculture on reservoir environment." Water Science and Engineering 4, no. 1,2011, pp. 92-100.

Solanki, Venkata Ramanaiah, S. Samba Murthy, Amarjit Kaur, and S. Sabita Raja. "Variations in dissolved oxygen and biochemical oxygen demand in two freshwater lakes of Bodhan, Andhra Pradesh, India." Nature Environment and Pollution Technology 6, no. 4 (2007): 623.

M. N. Kutty (1987) Introduction to aquaculture: Site Selection for Aquaculture, Physical Features of Water", RAF/82/009. Port Harcourt, Nigeria: UNDP/FAO/Nigerian Institute for Oceanography and Marine Research Project.

P. B. Utang, and Happiness E. Akpan. "Menu." Journal: Research Journal of Environmental and Earth Sciences 4 (2012): 34-40.