Occurrence and prevalence of fish parasites and the interaction with water quality parameters in selected small water bodies in western Kenya

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Abstract

Water quality and the environment greatly influence the existence and proliferation of parasites in the water and consequently, fish. This can have profound implications on aquaculture within the water bodies. Few studies have been conducted on parasite aggregations about the water quality in small water bodies in Kenya. This study assessed the suitability of selected Small Water Bodies (SWBs) for aquaculture as regards fish parasites by assessing the relationship between the occurrence and prevalence of parasites to water quality, water depth, land use, and shoreline habitat type. Standard protocols and procedures were used in the collection, analysis of water quality, and assessment of fish specimens for parasitology. White spot disease, (a parasite with economic significance) was in 4 of the 6 SWBs studied and had varying prevalence rates ranging between 10% to 20%. Clinostomum, a zoonotic parasite was also recorded in one of the SWBs sampled in this study. Additionally, the study realised some significant differences in the water quality from the various selected SWBs ($p<0.05$), which could be a pointer to the noted diversities in the parasite communities. The findings of this study indicated that there was a strong positive correlation (r2 > 0.8) between some parasites (*Ichthyopthirius multifiliis*, *Clinostomum spp.*, *Procamallanus*, and *Camallanus*) and some water quality parameters (temperature, turbidity, Soluble Reactive Phosphorous, Total Phosphorous, and Silicates). In light of the increase in focus on fisheries and aquaculture as key drivers of the blue economy and food and nutrition security, and as the country explores new frontiers for investment in aquaculture in SWBs, the water quality and consequent habitat features such as depth and land use, need to be addressed before investment.

Keywords: *Small water bodies (SWBs), Water quality, Nutrients, Parasites, Prevalence, Aquaculture*

1.0 Introduction

Aquaculture has grown very rapidly in Kenya in the past decade, playing a vital role in the national fish supply and food security. Additionally, in doing this, it has resulted in the creation of many employment opportunities, directly and indirectly, hence promoting incomes to various households (Orina et al., 2018). The rapid growth of this sector in Kenya has seen it ranked 4th major producer of aquaculture in Africa producing about 24,096 MT annually as of 2014 (KMFRI, 2017) Government interventions in the last two decades has seen this sector increase its vibrancy, thus moving from extensive systems to mainly intensive systems to meet the rising demand for fish.

Small water bodies (SWBs) can be described as small water reservoirs which can have various aspects of water quality and chemistry which determine the kind of species they support (Arthington et al., 2016). The potential of SWBs in aquaculture in Kenya has not been fully utilized, with most interventions focusing on large water bodies like lakes, oceans, etc. Few studies have been done on the potential of SWBs in aquaculture in Kenya. There is an increase in focus on fisheries and aquaculture as key drivers of the blue economy and food and nutrition security (Fondo and Ogutu, 2021). Additionally, with the declining capture fisheries and with the need to boost aquaculture production, SWBs offer a new frontier to increase fish production in Kenya. The utilization of water bodies including SWBs for aquaculture depends on a myriad of factors including but not limited to; water quality, bathymetry, and competition with other resource users (Gambi & Mzengera, 2016). Various SWBs have been identified as potential areas for the exploitation of cage aquaculture to increase fish production in the country. Biological components especially the occurrence and prevalence of fish parasites in these water bodies can determine their viability of aquaculture potential (Opiyo et al., 2018).

Diseases and parasites are real threats to an aquaculture establishment. Disease occurrence is one of the main challenges that hinder the sustainable production in aquaculture systems which increases with the rise in intensification as seen in most if not all aquaculture enterprises (Mugimba et al., 2018; Reverter et al., 2021). High parasite loads (ectoparasites or endo-parasites) significantly contribute to decreased fish growth, mortalities, and market unacceptability culminating in undesired aquaculture losses (Wanja et al., 2020). Generally, fish diseases can be attributed to infections due to introduced fish, contamination by transportation containers, avian spread, intermediate host population rise, malnutrition, lack of seed traceability, and disease ambient conditions (Okaeme et al, 1999). This rapid assessment aimed to provide a baseline study of selected SWBs in the western region of Kenya for their suitability in aquaculture. The study assessed the possible influence of the adjacent land use characteristics, water depths, water quality, and respective parasite occurrence, and their potential applicability for aquaculture.

2.0 Materials and Methods

Study area

The assessment was conducted in 6 (six) small water bodies each located in 6 counties. Munana (Busia county), Uranga (Siaya county), X rasa (Kakamega county), Huma (Kisumu county), Pap Orage (Homabay county), and Olasi (Migori county) were the small water bodies dealt with. Those areas were selected to identify their potential applicability to supplement fish for the country and eventually help reduce the pressure from capture fisheries in Lake Victoria, with the increased exploitation.

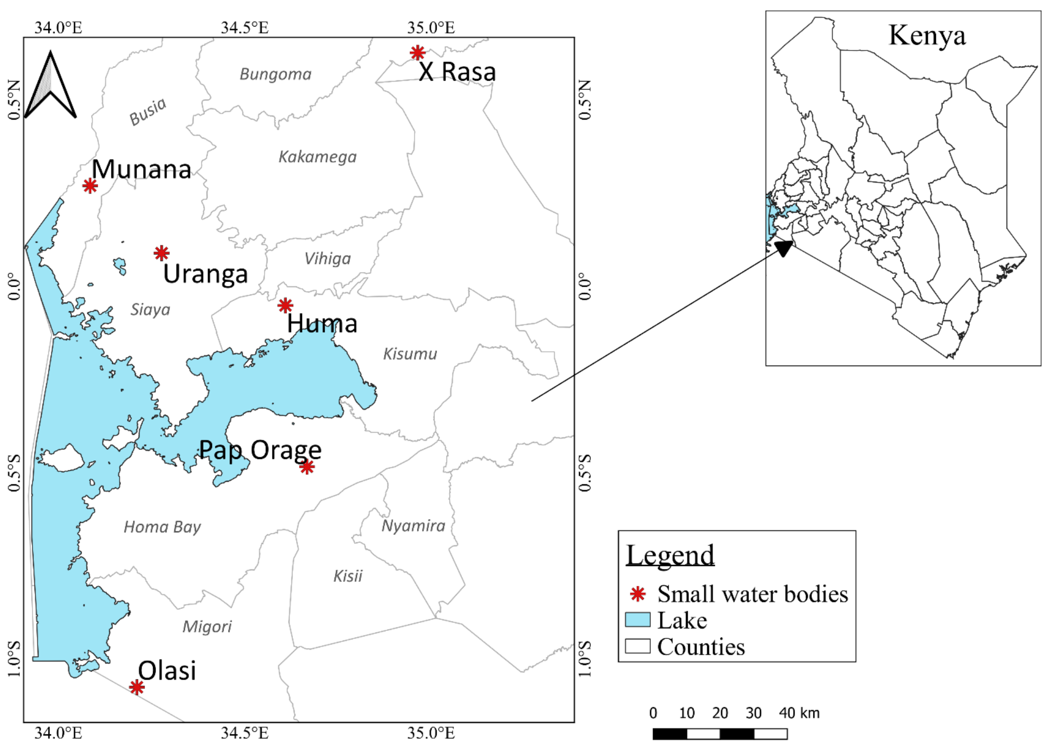


Figure 1: *Map of the study area showing Pap orage, Olasi, Huma, X-Rasa, Uranga, and Munana small water bodies in Homabay, Migori, Kisumu, Kakamega, Siaya, and Busia counties respectively.*

Fish samples were collected using a beach seine 50 meters long with a depth of 3 meters and a stretched mesh size of 1". Fish measurements (morphometrics) were taken; length by using the measuring board to the nearest cm and weight; using the weighing scale to the nearest gram. Additionally, fish were identified to species level. The health status of fish was assessed following the standard fish health diagnostic protocols (Aloo, 2012). Additionally, feedback from the aquaculture structured questionnaires on diseases was used to complement the field study.

Assessment of water characteristics followed published standard methods for aquatic environmental studies (APHA, 2012). Portable water Physico-chemical electronic sensor-based probes were used to take in situ water quality measurements at the dams. The main physical and chemical parameters measured were; column depth (m), temperature (^{o}C), dissolved oxygen (mg^{-1}), pH, turbidity (Formazin Turbidity Units -FTU), and Total Dissolved Solids (TDS) (age^{-1}). Water transparency measured as Secchi depth (photic depth) was measured using a standard Secchi disk of 20 cm diameter.

This study also investigated the levels of nitrogen (ammonium-NH_4^+-N; nitrite-NO_2^--N; nitrate-NO_3^-- N; total nitrogen-TN), phosphorus (soluble reactive phosphorus-SRP; total phosphorus-TP), and silicate species concentrations on all the study sites. Chlorophyll-a, a measure of levels of primary production which acts as the primary energy source for the heterotrophs was also measured.

Sampling sites were identified (two at the littoral areas and one at the center) and triplicates were collected for each station. The samples were then composited to make one sample per station. Water samples were collected using a Van Dorn water sampler at the surface. The water samples for soluble nutrient fractions were then filtered and stored in polyethylene bottles under refrigeration at about 4°C for further laboratory analyses. Samples for TN and TP were refrigerated without filtration. Samples for chlorophyll-a were filtered using GF/C filters, securely wrapped in aluminum foil before refrigeration at about 4 ^{0}C. The samples were later on transported to the laboratory and analyzed according to methods adopted from APHA 2012.

3.0 Results

3.1 Water quality

Findings from the study indicated varying levels of interactions in the environment that were informed by various reasons as depicted in Figure 3. The Secchi depth in all the small water bodies was relatively low, indicating high turbidity in the water column. However, Olas had the highest turbidity levels. This could be because the dam was under rehabilitation with freshly constructed dykes. The dam was characterized by loosened sediments, bare shores, and banks. The surrounding areas were covered by scanty trees mainly euphorbia. Munana dam had the highest TDS values which could be attributed to the fact that the dam was a multiple-user water body, allowing for watering of the domestic animals. The effect of this was a disturbance of the substrate as a result of the animals' activity. Dissolved oxygen, a vital component in the survival and growth of fish was relatively low (below 3mg/L) in Pap orage and Uranga dams.

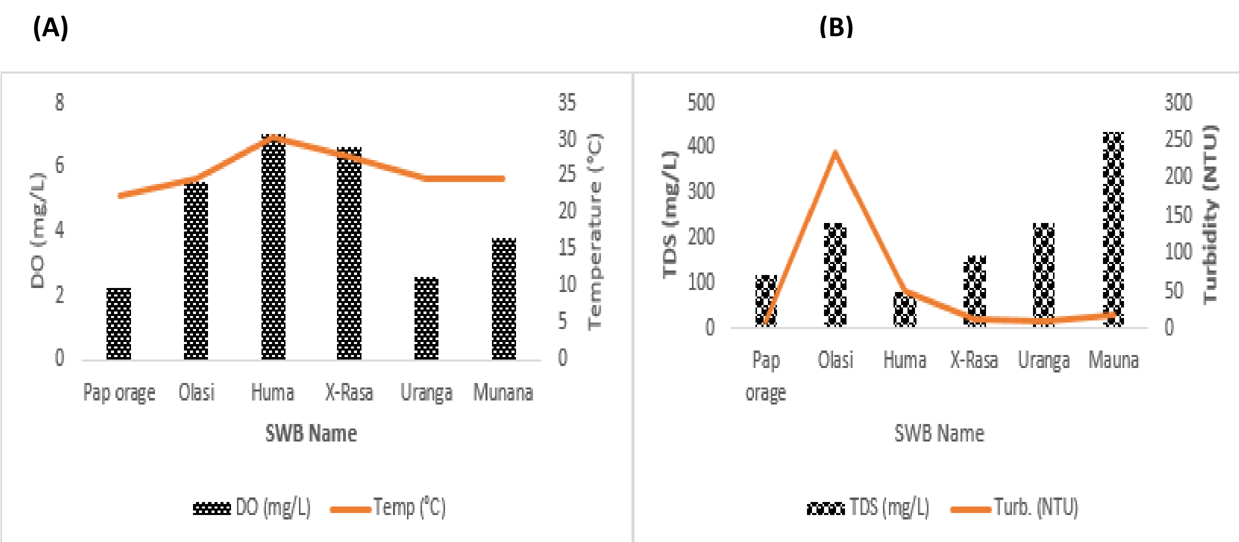


Figure 2: *Water quality parameters of the sampled SWBs observed during the sampling.* ***(A)*** *Dissolved oxygen values and* ***(B)*** *Combined water quality parameters.*

Nutrients and Chlorophyll had a relatively different pattern of distribution as depicted in Figure 3. Pap Orage and Olasi dams had the highest ammonium and TP levels respectively in all the dams.

Chlorophyll a and Nutrients

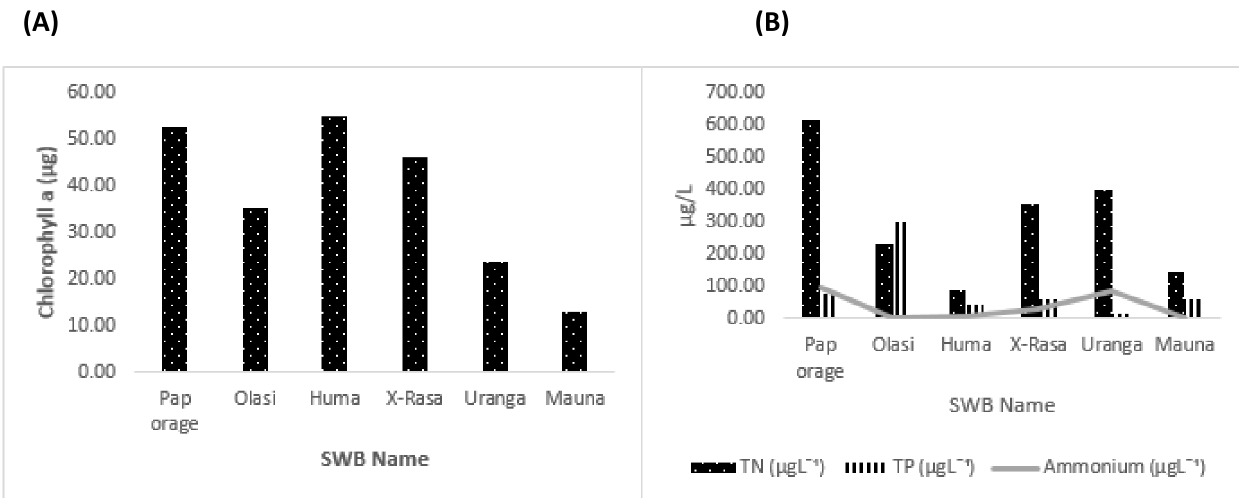


***Figure 3**: Chlorophyll-a **(A)** and nutrient **(B)** concentrations in the SWBs sampled.*

3.2 Habitat characteristics

***Table 1**:* Representation of the dam, habitat type, and surrounding land uses of the sampled small water bodies during the study.

Dam	***Shoreline habitat type***	***Surrounding land use***
Pap Orage	Vast mixed bare ground and grass cover. Sedges on the western shores and rocky outcrops on the northern shores. Planted eucalyptus further out. Muddy: shrubs.	Grazing fields for livestock.
Olasi	A dam under rehabilitation with freshly constructed dykes. Bare shores and banks from construction. Basin characterized by scanty trees of mainly euphorbias. Muddy: grassland.	No activity in the direct surroundings.
Huma	Dam outflows into banks. Marshland. Muddy: grassland.	Minimal activities in the surroundings.

X – Rasa	Shrunk dam due to siltation. Dam fed by natural springs but no visible outlet. Palm trees around the dam. Mostly grassy; few hydrophytes in the waterline. Sandy: grassland	Minimal activities in the surroundings.
Uranga	Irregularly shaped water mass with multiple sheltered bays and a wide-open main body. Inflow through a permanent stream while outflow is through a controlled channel. Dense macrophyte cover (Typha, phragmites, and a few higher shrubs).Water lettuce spreading out into the main body Muddy: shrubs	Water from the dam is mainly used for local irrigation.
Munana	A dam was constructed within a permanent swamp and a stream basin. The presence of floating water lilies covers about 90% of the water surface. A water intake and pumping station are located at the outflow/ downstream side. The dam has cement-protected rectangular banks. Vegetation comprising of mixed shrubs and Typha on the shore sides; Sandy: shrubs	Dam water is abstracted for domestic use and aquaculture.

3.3 Occurrence and prevalence of parasites

This study found an array of various parasites both ectoparasites and endoparasites from the different fish caught with various prevalences. Olasi dam had the richest diversity of parasites. White spot disease (*Ichthyopthirius multifiliis*) was present in all the dams apart from Uranga and X-Rasa

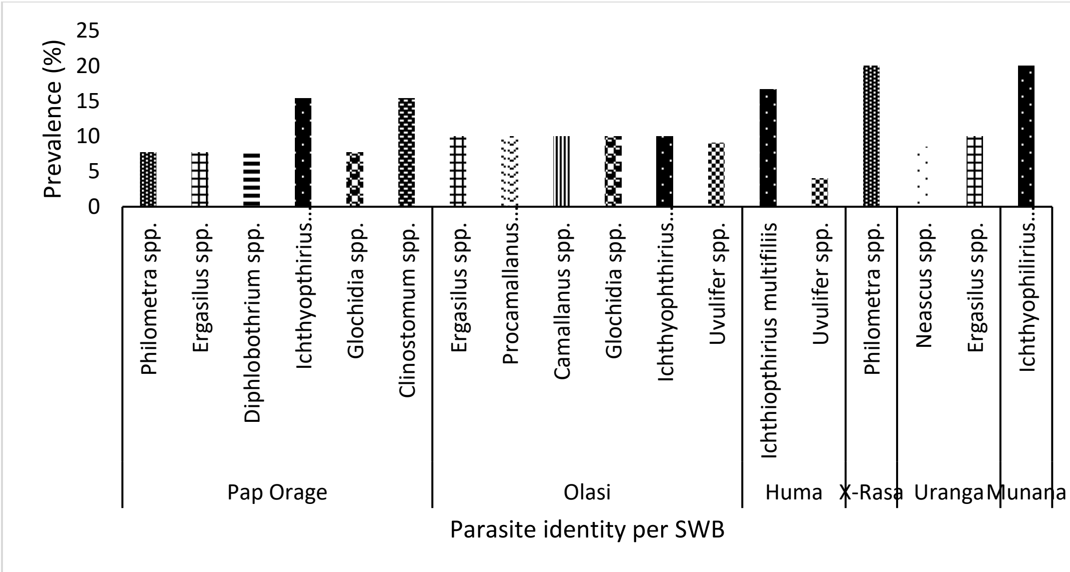
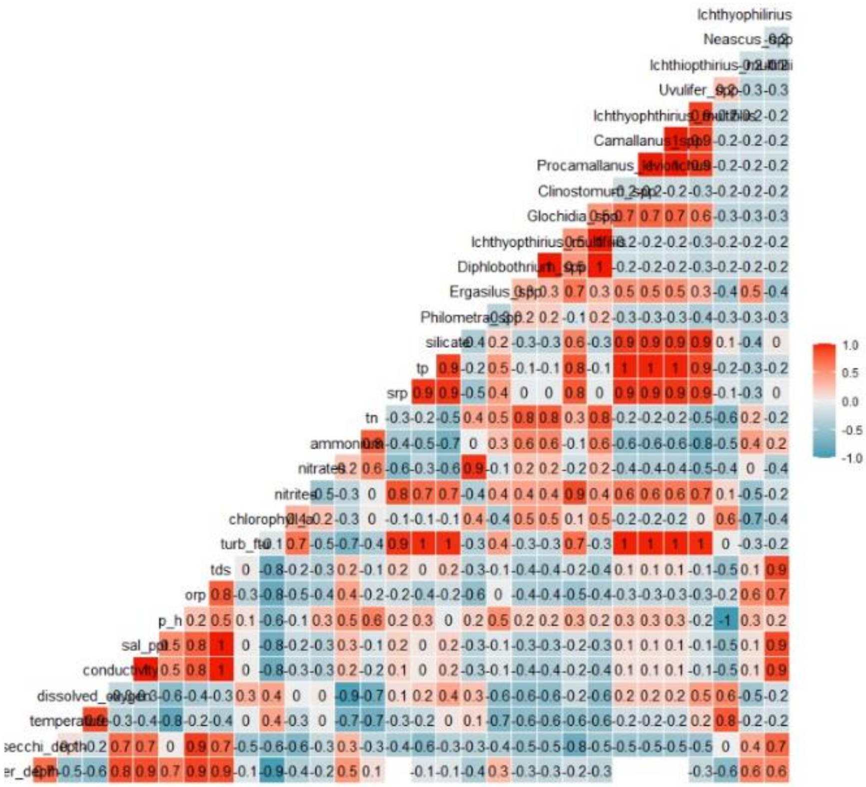


Figure 4: *Type and prevalence of parasites in the various several water bodies sampled during the study period.*

Correlation between water quality and occurrence of the various parasites in the SWBs

The study set out to investigate the possible interactions between the various parasites observed and water quality as shown in Figure 5 below. There was a marked strong positive correlation between Turbidity, SRP, TP, and Silicates on *Clinostomum spp*., *Procamallanus spp*., *Camallanus spp*., and *Ichthyopthirius multifiliis* during the study as illustrated below.



Note: *The darker the color the higher the positive correlation hence the more the relationship between/among the variables in question.*

Figure 5: *Gg plot of the correlation between water quality parameters and various parasites in the SWBs.*

4.0 Discussion

Currently, the production of fish in Kenya is not able to meet the demand hence the rising interest in aquaculture to address the deficit (Wanja et al., 2020). Efforts in promoting aquaculture have resulted in the establishment of several projects to encourage investment in this area. However, with varying water uses in Lakes, rivers and the inability to fully explore the EEZ in the oceans, the focus is being shifted to the utilization of the small water bodies (SWBs). Small water bodies in Kenya are a viable option for investment in aquaculture in its quest to boost fish production. This study which was conducted in selected small water bodies within the Western region was to provide a rapid assessment of the SWBs for the potentiality for use in aquaculture by considering various factors; depth, land use, shoreline characteristics, water quality, and lastly; parasite occurrence, abundance, and diversity.

The influence of adjacent land use characteristics and user conflicts can be varied and contribute significantly to the success or failure of any aquaculture intervention for a certain water body (Maina et al., 2017). An example in this study is the Uranga dam. The dam had a high potential for application in aquaculture, but due to the agricultural activities in the surroundings, the potential risks for interference as a result of using agricultural inputs could pose a challenge. Agricultural inputs particularly fertilizers can be drained into the water bodies during the rainy seasons and result in elevated levels of some nutrients. Interestingly though are the relatively high concentrations of Total Phosphorus (TP) in Olasi dam which had no agricultural activities taking place around it. A probable reason for this could be the fact that since this SWB did not have an outlet, there was an exaggerated accumulation of nutrients in which the reservoir could be acting as a sink. The contribution could be due to runoff passing through farmlands ending up in the dam. These observations are similar to those seen in the Ngei dam as reported by Kaggwa et al., (2011) which showed exceptionally high levels of both TP and Silicates throughout the study period within this dam that also lacked an outlet. These high levels of nutrients can have negative impacts on fish especially by encouraging algal blooms in the SWBs.

The success of utilization of an SWB for aquaculture and the system to set up is heavily dependent on its depth profile. This study found the depths of the SWBs to range between 1m to 3m. These depths were below those recommended for cage aquaculture (Orina et al., 2018), hence if this system is to be applied, dredging needs to be incorporated. However, for utilization in general pond aquaculture, all the dams, apart from Huma dam are good candidates since their depths ranged between 1m and 3m. At these depths, phytoplankton productivity is regulated and not in excess, and additionally, there is a better flow of nutrients and oxygen. Secchi depth; is another important factor that should guide the suitability of water for fish culture. From this study, Huma, Xrasa, Uranga, and Munana had Secchi values within the recommended range of 30cm to 60cm. At those Secchi depths, there is good fish production and sufficient shading for the underwater weeds which act as refugia for fish and also as spawning sites. On the contrary, a Secchi of below 30cm (as is the case in Pap Orage and Olasi SWBs, issues of dissolved oxygen problems are rampant. Above 60cm, the growth of underwater macrophytes is promoted, and consequently, there is less phytoplankton which is food for fish (Boyd, 1985).

Out of the sampled SWBs in this study, the most suitable candidates are Xrasa (Kakamega county) and Uranga (Siaya county). This is because in addition to the fact that they had a lower parasite prevalence, their water quality characteristics, accompanying shoreline features and habitat use can be accommodative of the venture. However, there is a need to consider dredging for better depth profiles. Pap Orage on the other hand was used for livestock grazing, and this excludes it as a potential candidate. This is because of the potential to harbor more parasites since livestock can be intermediate hosts of some parasites (Walakira et al., 2014), hence this would encourage the proliferation of those parasites. Additionally, user conflicts could arise which would then hamper the optimal performance of aquaculture activities. Pap Orage and Olasi had a wide diversity of parasites which would possibly make them unsuitable for aquaculture. Of concern is the appearance of *Clinostomum spp.* and *Diphyllobothrium spp*. (parasites of zoonotic significance) in Pap Orage with a relatively high prevalence. Additionally, this SWB had significantly high levels of microbial contamination (700/100cfu) which is indicative of fecal contamination.

Before investment in aquaculture of any water body, it is vital to conduct a water quality analysis to assess its suitability for applicability while considering sustainability and value for investment (Anyadike et al., 2016). The study found a positive correlation between Turbidity, SRP, TP, and Silicates with some fish parasites; *Clinostomum spp*., *Procamallanus spp*., *Camallanus spp*., and *Ichthyopthirius multifiliis*. This could point to the fact that due to available nutrients, then the growth of the host is favored and in addition, there is a free flow of nutrients for the parasite and its infective stages (Bhatnagar and Devi, 2013). A related study on parasite communities and related water quality parameters in Lorwai swamp and Lake Baringo, Kenya also reported a positive correlation between nutrients and the abundance of *Clinostomum* spp. in fish (Adamba et al., 2020).

5.0 Conclusion

The study found that the various parameters aforementioned all work in tandem to ensure a viable investment. It is therefore important to ensure that before utilization of an SWB for aquaculture, proper analysis is done to ensure that there is no conflict of interest with various users. The source of water for the SWB is also key since it will inform about the performance of the fish to be stocked. Generally, the study found that restocking of the SWBs could be the best option, as opposed to exclusive utilization for fish culture due to the various uses they are applied for hence avoiding conflicts of interest.

6.0 References

Adamba, KWS., Otachi, EO. And Ong'ondo, GO. (2020). Parasite Communities *of Oreochromis niloticus* baringoensis (Trewavas, 1983) about Selected Water Quality Parameters in the Springs of Lorwai Swamp and Lake Baringo, Kenya.

Aloo, P. A comparative study of helminth parasites from the fish *Tilapia Zilli* and*Zillichromis leucostictus* in Lake Naivasha and Oloidien Bay, Kenya. *Journal of Helminthology*.76 pp. 95-102

Anyadike, C., Mbajiorgu, C., & Ajah, G. (2016). Review of Aquacultural Production System Models. *Nigerian Journal of Technology*, 35(2), 448. https://doi.org/10.4314/njt.v35i2.29

Arthington, A. H., Dulvy, N. K., Gladstone, W., & Winfield, I. J. (2016). Fish conservation in freshwater and marine realms: status, threats, and mana,gement. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 26(5), 838–857. https://doi.org/10.1002/aqc.2712

Bhatnagar A, Devi P (2013) Water quality guidelines for the management of pond fish culture. *International Journal of Environmental Sciences*, 3(6):1980–2009

Gambi C. and Mzengera K. (2016). Compliance and Enforcement of the Fisheries Regulations on Lake Malawi in Nkhatabay District. *Oceanography & Fisheries Open Access Journal*, 1(2). https://doi.org/10.19080/ofoaj.2016.01.555557

Fondo E. and Ogutu, B. (2021). Sustainable crab fishery for the blue economy in Kenya. *Aquatic Ecosystem Health & Management*, 24(1): pp.21–26

Kaggwa, M.N., Liti, D., Schagerl, M. (2011). Small tropical reservoirs and fish cage culture: a pilot study conducted in MachaDistrictrict, Kenya. *Aquaculture International* 19 pp. 839–853

KMFRI (2017). Kenya's Aquaculture Brief 2017: Status, Trends, Challenges and Future Outlook. Kenya Marine and Fisheries Research Institute, Mombasa, Kenya. 12pgs.

Maina, K. W., Mbuthia, P. G., Waruiru, R. M., Nzalawahe, J., & Murugami, J. W. (2017). Risk factors associated with parasites of farmed fish in Kiambu County, Kenya. *International Journal of Fisheries and Aquatic Studies*, 5(4), 217–223.

Margolis, L., Esch, G. W., Holmer, J. C., Kuris, A. M. and Schad, G. A. 1982. The use of ecological terms in parasitology, (Report of an Ad Hoc Committee of the American Society of Parasitology). *Journal of Parasitology*,68: 131-133.

Mugimba, K. K., Chengula, A. A., Wamala, S., Mwega, E. D., Kasanga, C. J., Byarugaba, D. K., Mdegela, R. H., Tal, S., Bornstein, B., Dishon, A., Mutoloki, S., David, L., Evensen, & Munang'andu, H. M. (2018). Detection of tilapia lake virus (TiLV) infection by PCR in farmed and wild Nile tilapia (*Oreochromis niloticus*) from Lake Victoria. *Journal of Fish Diseases*, 41(8), 1181–1189. https://doi.org/10.1111/jfd.12790

Opiyo, M. A., Marijani, E., Muendo, P., Odede, R., Leschen, W., & Charo-Karisa, H. (2018). A review of aquaculture production and health management practices of farmed fish in Kenya. *International Journal of Veterinary Science and Medicine*, 6(2), 141–148. https://doi.org/10.1016/j.ijvsm.2018.07.001

Orina, P., Ogello, E., Kembenya, E., Githukia,C., Musa, S., Ombwa, V., Mziri, V., Abwao, J., Ondiba, R., Okechi,J. (2018). STATE OF CAGE CULTURE IN LAKE VICTORIA, KENYA. KMFRI Research Report No. AQUA/ FWS/2017-2018/5.

Orina, S., Ogello, E. O., Kembenya, E. M., & Muthoni, C. (2018). State of Cage Culture in Lake Victoria, Kenya (Issue June 2019). https://www.researchgate.net/publication/333805185_State_of_Cage_Culture_in_Lake_Victoria_Kenya

Otieno, N. O., Kitaka, N. and Njiru,J. M. 2014. Length-weight relationship, condition factor, length at first mate,rity and sex ratio of Nile tilapia, *Oreochromis niloticus* in Lake Naivasha, Kenya. *International Journal of Fisheries and Aquatic Studies* 2(2): pp.67-72

Reverter, M., Tapissier-Bontemps, N., Sarter, S., Sasal, P., & Caruso, D. (2021). Moving towards more sustainable aquaculture practices: a meta-analysis on the potential of plant-enriched diets to improve fish growth, immunity, and disease resistance. *Reviews in Aquaculture* (Vol. 13, Issue 1, pp. 537–555). Wiley-Blackwell. https://doi.org/10.1111/raq.12485

Walakira, J., Akoll, P., Engole, M., Sserwadda, M., Nkambo, M., Namulawa, V., Kityo, G., Musimbi, F., Abaho, I., Kasigwa, H., Mbabazi, D., Kahwa, D., Naigaga, I., Birungi, D., Rutaisire, J., & Majalija, S. (2014). Common fish diseases and parasites affecting wild and farmed Tilapia and catfish in Central and Western Uganda. *Uganda Journal of Agricultural Sciences*, 15(2), 113–125.

Wanja, D. W., Mbuthia, P. G., Waruiru, R. M., Mwadime, J. M., Bebora, L. C., Nyaga, P. N., & Ngowi, H. A. (2020). Fish Husbandry Practices and Water Quality in Central Kenya: Potential Risk Factors for Fish Mortality and Infectious Diseases. *Veterinary Medicine International*, 2020. https://doi.org/10.1155/2020/6839354