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STRATEGIC ENVIRONMENTAL ASSESSMENT OF VISITOR PERCEPTION, EBOLA RISK FACTOR, AND WATER QUALITY OF MOLE NATIONAL PARK FOR SUSTAINABLE ECOTOURISM FUNCTIONS

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Abstract:

Aligning with Parks' sustainability, tourist perceptions about integral field conditions for ecotourism functions were studied at Mole in Ghana (Africa) through periodic physicochemical analyses of water using (APHA/AWWA/WEF, 2012) protocols. Optimally, 81.5 wet days with 1,107.38mm rainfall intensity- regulated the park's dynamic natural primary productivity within six years interval (2005 to 2010), revealing direct insignificant regressive linear relationships ($y = 1.7x + 0.2778$) in the rainfall pattern interspersed with marginal variations in standard errors of the month-by-month figures ($R2 = 0.6839$). Zero Ebola records status boosted ecotourism functions, although, foreign visitors' statistics dropped in 2014 with reciprocal ascendance of locals when the Government of Ghana adopted WHO/CDC Ebola preventive interventions. Routine carrying capacity measures regulated tourist numbers annually. Ground littering, pool contamination, olfactory wild animal odours, and higher entrance fees seldom discouraged 90-95% of the subjects who considered the park's environs as recreationally moderately attractive. $CaCO3$ varied widely from 32.03 to 124.72 mg/L similar to turbidity (1.27 - 57.4) NTU, while pH remained neutral (7) in the entire park's water resources. Boreholes temperatures varied slightly between Laribanga (23.7°C) and Mole (27.8°C) whereas, EC differed significantly ($p<0.05$) between Mole dam 1b (47.6 µS/cm) and Mole pool (2181 µS/cm). A few water sources exhibited lower TDS, though higher figures also exceeded the Ghana EPA standard (100mg/L), reducing its safety for recreational occupancy. Prognosis integral responses towards improving these water resources by redefining acceptable quality index, modelling of synergies using existing park's natural resources databases could posterity wise, secure, or improve ecotourism benefits.

Keywords:

Mole, Tourist Perception, Water Quality, Ebola, Ecotourism, Sustainability

Introduction

Historically and scientifically, a national park is a strictly reserved and protected area by a national authority for conservation purposes, often it is a reserve of natural, semi-natural, or developed land that a sovereign state declares or owns (Europarc Federation, 2009). Although individual nations designate their national parks differently, the commonest idea is the conservation of wild nature for posterity and symbolic national pride (Europarc Federation, 2009). National parks are usually open to visitors to provide outdoor recreation and camping opportunities (United Nations, 2014). Parks offer for scientific research, recreational satisfaction and income generation of nations with higher ecotourism potential (*ANPA, 2012)*.

Recent 2017 World Bank Report of the World Travel and Tourism Council (WTTC) on travel and tourism economic impact analysis unveiled that ever-increasing terrorist attack, political instability, health pandemics and natural disasters at sites affect tourism. In spite, the sector travailed, contributing direct GDP growth of 3.1% and supporting 6 million net additional jobs.

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In totality, travel and tourism generated US$7.6 trillion (10.2% of global GDP) and 292 million jobs, equivalent to 1 in 10 jobs in the global economy in 2016 (World Bank/WTTC, 2017). The sector accounted for 6.6% of total global exports and almost 30% of total global service exports. For the sixth successive year, growth in travel and tourism outpaced that of the global economy (2.5%). In 2016, direct travel and tourism GDP growth not only outperformed the economy-wide growth recorded in 116 of the 185 countries covered by the annual economic impact research in major travel and tourism economies such as Australia, Canada, China, India, Mexico and South Africa, but was also stronger than growths in the financial, business, manufacturing, public services, retail and distribution and transport sectors. Outlook for the travel and tourism sector in 2017 robustly continued to be at the forefront of wealth and employment creation in the global economy, despite the emergence of a number of challenging headwinds (World Bank/WTTC, 2017).

The United Nations, therefore, designated 2017 the International Year of Sustainable Tourism for Development in recognition of potential national contributions (World Bank/WTTC, 2017). Tourism is one of the fastest growing and most dynamic sectors of Africa's economy. Despite unprecedented challenges, including the Ebola outbreak in West Africa during 2014, the sector has tremendous potential to create jobs, boost inclusive economic growth across the continent and reduce poverty (Africa Tourism Monitor (ATM), 2015). In 2014, tourist arrivals in Africa increased overall by 200,000 over the previous year. Arrivals in Egypt rebounded in 2014 with a 5% increase, equating to 454,000 more visitors than the prior year. Morocco maintained its record of surpassing 10 million arrivals for the second consecutive year. Additionally, Côte d'Ivoire showed promise with a 24% increase in arrivals by 91,000 more visitors than in 2013. In 2014, the tourism sector encountered challenges with the Ebola crisis in the Sub-Saharan Africa Region although, the sector directly contributed GHS2.62bn ($727m) to Ghana's GDP in 2013, or 3% of the total and the country attracted around 930,000 visitors in 2014, down slightly from roughly 1m in 2013, due to a number of factors, including the global economic situation, but most significantly the outbreak of Ebola in West Africa in December 2013(World Bank Report 2017; Osei-Bonsu, 2016). This nudged the country above the global average of 2.9%, though it lagged behind the regional frontiers such as Gambia (9%), Senegal (5.3%) and Kenya (4.3%).

From this modest but solid base, robust growth is expected (WTTC forecasts annual average sector growth of 4.5% between 2014 and 2024)**.** While as of mid-2015 there had been no cases of Ebola in Ghana nor its immediate neighbours, the Ebola outbreak had a significant impact on tourism, partly due to a perception of risks in the region among oversees visitors. Arrivals were also affected by limitations put on travel from other countries in West Africa. The Government of Ghana (GoG) suspended local and international conferences between September 2014 and January 2015 to reduce risks of the contagion (Osei-Bonsu, 2016). Local press reports cited a resort near Cape Coast where arrivals from Europe had fallen by half and those from the USA by 80%. Ghana anticipated a strong rebound in 2015, optimistically forecasting 1.5m arrivals. The lifting of the ban on conferences, the easing of the Ebola crisis elsewhere and Ghana's clean record on the disease could contribute to recovery. The Ghana Tourism Authority (GTA) stages a previous target of attracting 5m tourists a year by 2027 and to perhaps be reached earlier if the country's tourism strategy, service standards and industry capacity are strengthened by new sector reforms. Improved reforms require adoption of integral approaches such as – strategic environmental assessment of the Ebola risk factor and water

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quality of major tourist sites like Mole National Park for sustainable ecotourism development, which constituted the subject matter of this scientific study report (Osei-Bonsu, 2016).

Methodology

Study Area

West Gonja District is located in the Northern Region of Ghana. It lies on longitude 1°5I and 2°58I West and Latitude 8°32I and 10°2I North. It shares boundaries in the south with Central Gonja, Bole and Sawla-Tuna-Kalba Districts in the West, Wa East District in the North West, West Mamprusi in the North and Tolon Kumbungu District in the East.

Figure 1a. Location of Mole National Park (in box) Near Damongo in Ghana

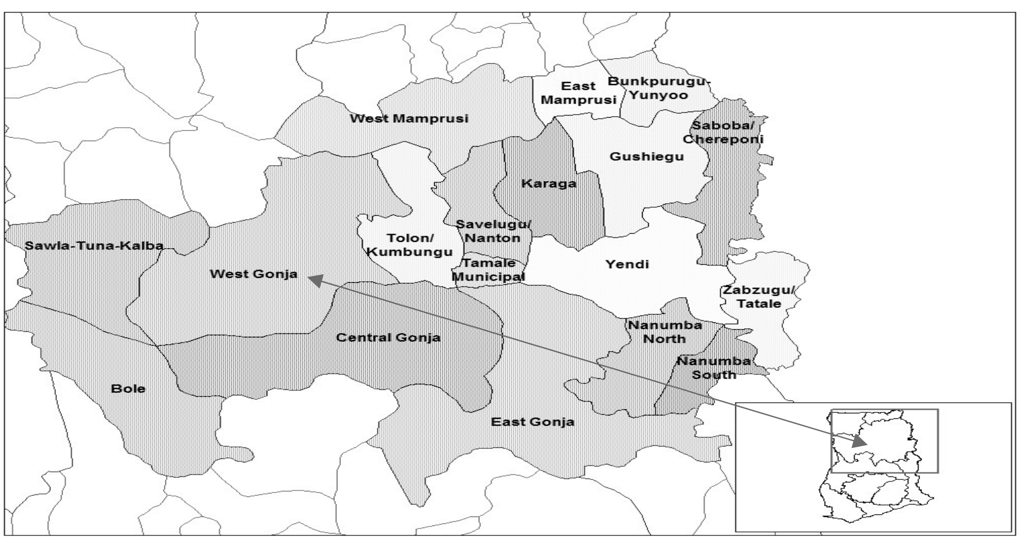

Figure 1b. Location of the West Gonja District in the Northern Region of Ghana

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West Gonja District constitutes total land area of 8,352 km2, about 12% of the total land area of the Northern Region with a population (76,702) at a density of 8.3 persons per Km2, below the regional density of 25.9 persons per Km2 at a growth rate of 3.1% higher than the regional (2.8%) and national (2.7%) respectively (Ghana Statistical Service (GSS), 2013). The topography is undulating with altitude of 150 - 200meters above sea level. The only high land is the Damongo Escarpment. Geologically, the area is characterized by Voltaian rock formation with isolated Cambrian rocks enriched with bauxite. Mudstones and sandstones persist in the Alluvial Damongo formations with few outcrops of weathered rocks around Daboya. The Mole River from the northern boundary joins the White Volta River east of Damongo and enters the Black Volta River around Tuluwe in Central Gonja District (GSS, 2013). The bimodal rainfall pattern which averagely yields 1144mm annual intensity, lasts from late April to late October with peak in June-July and prolonged dry spells in August. Common trees species include patches of sheanut (*Vitellaria paradoxa*), dawadawa (*Parkia biglobosa*), baobab (*Adansonia digitata*), acacia (*Senegalia berlandieri*), and ebony *(Diospyros ebenum).* The original vegetation around major settlements (Damongo, Busunu, Mankarigu and Daboya) has been damaged by human activities. The West Gonja District has two nature reserves namely, Mole National Park and Kenikeni Forest Reserve both occupying 3,800Km^2 (30%) of the land area with rich array of flora and fauna. Mole Park, located about 30 km west of Damongo (the Savannah Regional Capital), is the largest in Ghana and one of the best managed wildlife parks in Africa, south of the Sahara Desert (Kuuder et al., 2013). Mole Park alone covers about 5500 hectares and is a major tourist attraction site for international visitors among the revised tourism sites in Ghana (Appendix Table 1).

Data Collection and Analytical Protocols

A questionnaire checklist was used to survey touristic potential of Mole based on perception analysis of the conditions that determine visitor satisfaction. Data were cross-examined and compared with Ebola risk situation of the park in relation to surrounding African countries (Funk and Piot, 2014). Rainfall data was pooled from the Ghana Meteorological Agency while, water quality physicochemical parameters were critically screened to determine its suitability for sustenance of ecosystem functions at Mole.

Application of the DPSIR Framework

The DPSIR framework/model has been developed and recommended in the late 1990s for use by the Organization for Economic Cooperation and Development (OECD, 2003) as a protocol for structuring and organizing variable indicators in a manner that is comprehensible for research decision makers (Gari et al., 2015). The protocol is based on previous methodologies within an environmental context, adopted as a conceptual framework by the European Environment Agency (EEA) in 1995 (Gabrielson and Bosch, 2003). The DPSIR is applied to analyse a cause - effect relationship between environmental and human systems and can be used as an analytical protocol in the study of water and other natural resource management issues (Ministry of Environment, Energy and Climate Change (MEECC), 2014c). It enables a comprehensive assessment of the issues through the examination of the relevant Driving forces (causes) and Pressures (pollutants) on the environment, State (quality) of the environment as represented by its Impacts (health of ecosystems), Responses (policies, targets) and the Interactions (cross-cutting effects) analyses among its key elements (Kristensen, 2004). Applications of DPSIR frameworks regarding water quality management issues also exist in the international and Greek literature (Agyemang et al., 2007; Lyra, 2015). Towards implementing the DPSIR framework in the study area, the sequences of pressures, states,

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impacts and responses engaged to each driver was presented as derived from the field data in accordance with the DPSIR methodology. This demonstrated an account of the periodic field data collected from the visitors and park resource persons using the Mole Park Management Plan as a standard guide, and rainfall data from the Ghana Meteorological Agency (2010). The driving forces taken into consideration in this strategic assessment included (1) Tourist population and perception analyses (2) Park facilities which determine ecotourism potential (3) Ebola records in the Sub-Saharan Africa Region (4) Rainfall pattern (5) Quality of water resources for ecosystem functions (6) Study area topography, geology, vegetation, land use and anthropogenesis.

Water Quality Assessment

Seven water bodies were mapped out based on proximity and accessibility within the park accessible areas. Water samples were then collected from these sites for three maximum weeks per season in the dry and rainy periods. The samples were stored in fresh sterile1.5 litres Voltic bottles, subsequently preserved in an ice chest at 4°C and transported to the Science Laboratory at University of Education, Winneba, Mampong-Ashanti Campus for analysis of the physicochemical parameters based on the Park's water resource quality index specification within 24 hours. Parameters with extremely low stability such as temperature, *p*H, electrical conductivity, total dissolved solids were measured directly on the field with appropriate sensor meters. Turbidity, total hardness and total dissolved solids were subjected to requisite laboratory analysis using Standard Methods for the Examination of Water and Waste Water (APHA/AWWA/WEF Vol. 15 No.2) (Carranzo, 2012).

Research Hypothesis on Water Quality Index Parameters:

1. Null hypothesis with Freeman's Two-Way Analyses of Variance (Ho): was that [distributions of Turbidity (NTU), *p*H, Temperature (°C), EC (µS/cm), TDS (mg/L), Total hardness (mg/L) and Alkalinity (mg/L) will be same across the water sites at Mole]:Hence, (Ho): H_2O (Turbidity = *p*H = Temperature = EC = TDS = TH = Alkalinity) of the entire water sites.
2. Alternative hypothesis with Freeman's Two-Way Analyses of Variance (Ha): was that [distribution of all the water parameters across the water sites will not be same at Mole: Hence, (Ha): H_2O (Turbidity ≠ *p*H ≠ Temperature ≠ EC ≠ TDS ≠ TH ≠ Alkalinity) of entire water sites.

Statistical Analyses

Raw data obtained from water analysis were tested and compared for their effective relationships using the Statistical Package for Social Sciences (SPSS Version 16) by means of Partial and Spearman's Correlation for (1-tailed test) and the asymptotic significance (2-tailed test). Further analyses of parameters at various water sites was conducted to validate the level of consistency within same sample site data sets among the parameters across sites with an Independent-Sample Kruskal-Wallis Test for continuous data. A Freeman's Two-Way Analyses of variance was run on ranked data to summarily highlight the level of significant differences (at $p<0.05$ level of significance) in distributed outcomes of various water parameters across the sites (Appendix Tables 12 and 13).

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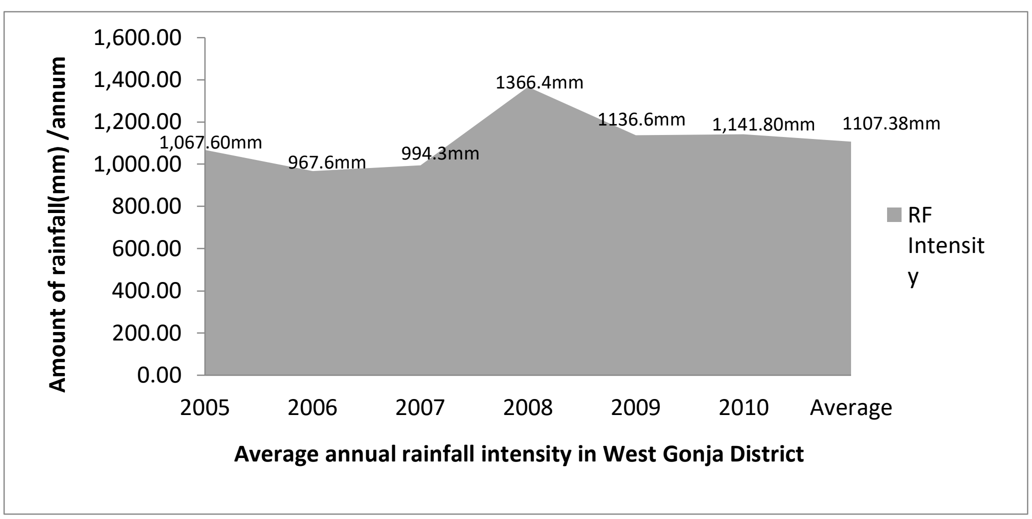
Results and Discussion

Rainfall and Recreational Facility Conditions at Mole National Park

The prevailing meteorological data revealed a typically single seasonal rainfall pattern distributed over the six years medium-term overview of dynamic ecosystem impact regulatory functions at Mole (Figures 2 and 3). There were about 81.5wet days with 1,107.38mm optimum rainfall per annum within six years interval from 2005 to 2010 casting a direct insignificant regressive linear relationship (y = 1.7x +0.2778) in the net distribution patterns, transposed with marginal variation standard error (R^2 = 0.6839) of the month-by-month rainfall figures between the intensity and number of wet days over a five-year total distribution period (Figure 4). Rainfall intensity and distribution can synchronize niche productivity for sustainable wildlife management functions within the park ecosystems (Ghana Meteorological Agency, 2010). Despite that Mole's ecological tourism environ is largely depicted annually by stable rainfall conditions which favors natural primary productivity, coupled park characteristics such as historic cultural, environmental, entertainment and miscellaneous components determine the extent of touristic value (Chart 1). These resources and artifacts enable the park to cater for the visitor's satisfaction on account of its broader fauna and floristic species composition and niche diversity (Kuuder et al., 2013). About 60% of the communities within Mole had access to portable water. The district constructed 195 boreholes, 3 hand dug wells fitted with pumps, 4 small town water systems,12 mechanized boreholes, 10 dams and 10 dug outs as of 2015 (GSS, 2013). The research of Wang et al., postulated the urgency with mapping out the dominant indicators of environmental sites for sustainability by further cross-examining issues relating to soil pollution and water quality from protected areas for revitalization of tourism initiatives in recent times. This could be achieved by thorough scrutiny of the relevant ecological DPSIRs interpreted as - driving forces (causes) and pressures (chemical pollutants) on the environment (water/soil and biodiversity), the subsequent state (quality) of the prevailing conditions as represented by its impacts (health, ecosystems), transposing responses (policies, targets) and the corresponding interactions among these elements (Wang et al., 2018). Historic record further justifies the links between DPSIR framework models and integration of water issues in the international and Greek literature (Agyemang et al., 2007).

Figure 2: Average Annual Rainfall Intensity in West Gonja District, 2005-2010



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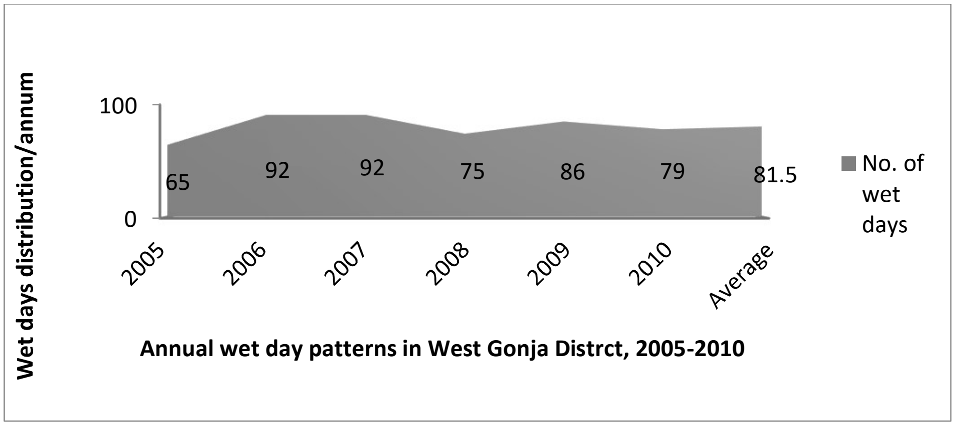

Figure 3: Annual Wet Day Patterns in West Gonja District, 2005-2010

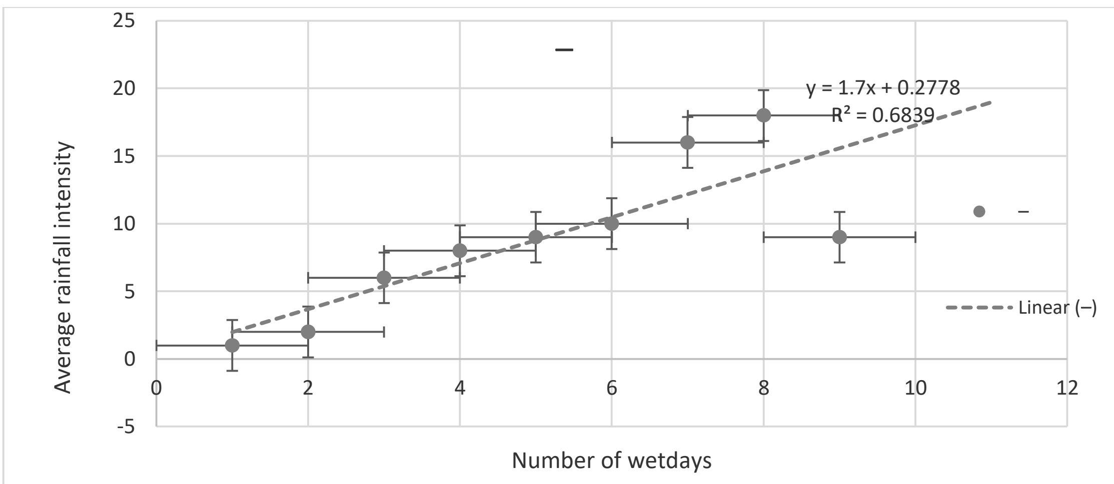

Figure 4: Rainfall Average Intensity and Wet Days in the Mole National Park (2005-2010)

Key: y = average rainfall intensity, x = average number of wet days and R^2 = regression between average monthly and annual rainfall intensity and number of wet days.

Tourists and Park Workers Perception and Environmental Hygiene Analyses on Ecotourism Potential of Mole

Table 1: Analysis of Domestic and Foreign Arrivals Pattern to Mole National Park (1997-2015)

Year	Local Tourists	% LV	Foreign Visitors	% FV	Total Visitors	Variation in successive year's visitor records (% increase or decrease in visitor ratios)
1997	1,978	42	2,759	58	4,737	58 LV : 58 FV precedent values
1998	1,708	30	3,896	70	5,604	10 dLV : 12 iFV
1999	1,591	31	3,502	69	5,093	1 iLV : 1 dFV
2000	1,876	35	3,549	65	5,425	4 iLV : 5 dFV
2001	2,918	51	2,836	49	5,754	24 iLV : 16 dFV

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2002	1,957	27	5,338	73	7,295	24 dLV: 24 iFV
2003	3,441	44	4,463	56	7,904	17 iLV : 17 dFV
2004	4,130	40	6,297	60	10,427	4 dLV : 4 iFV
2005	5,414	43	7,108	57	12,522	3 iLV : 3 dFV
2006	5,117	40	7,617	60	12,734	3 dLV : 3 iFV
2007	5,512	40	8,222	60	13,734	% LV : %FV was equal/constant
2008	8,048	48	8,759	52	16,807	8 iLV : 8 dFV
2009	6,890	47	7,870	53	14,760	1 dLV : 1 iFV
2010	6,141	43	8,195	57	14,336	4 dLV : 4 iFV
2011	7,883	54	6,816	46	14,699	11 iLV : 11 dFV
2012	Missed data (MD)	MD	MD	MD	MD	MD
2013	MD	MD	MD	MD	MD	
2014	6,000		6,000		14,600	Ebola accounted for some missed data (MD)
2015	12,000		4,000		17,800	

Sources: Mole Park Administration (2012 – 2015)

Table 1 data elucidate percent increment of visiting local tourist (iLV) at Mole Park which ultimately resulted to a reciprocal 8% percentage decease in the number of foreign visitors (dFV) in the successive years except in 2006 and 2007 when the percentage foreign and local visitors booked were steadily 40% and 60% respectively. Decline in visiting local tourists (dLV) numbers in the park ultimately gave rise to equal percentage

Table 2: Perception of Workers and Tourists on Environmental Quality, Hygienic Practices at Mole

Background of tourists				Old/ regular visitors	First time visitors	Remarks on aspect of the park's experience that amazes subjects most	
Origin	Female	Male	Total (%) freq.	% Freq.	% freq.	Visitors	Park workers
UK	6	7	13	3	10	Swimming pool adventure, wild animal spot views on safari ride, ecological interactions within the wallowing (small dams), surface water pollution, beautiful vegetation, bush burning problems, elephant, baboon and warthog.	1. Quality of services given to clients at the motel and field guarding. 2. Visitors enjoy more of safari views but success of spot varies and is more convenient early mornings and late evenings than other times of the day.

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						Good canteen services at the motel. Sense of willingness of tourist guards and caterers to help clients is satisfactory enough.	3. Clients require a lot of security and tend to ask a lot of challenging questions which require correct answers. Adequate preparation, vigilance and discipline are urgently required.
USA	10	12	22	4	18	Open Park environment is welcoming. Safari wild animal spot view entertaining and educative. Pollution of wild animal wallowing pond (odours emitted).	Effects 1, 2 and 3 above all apply
Germany	6	15	21	3	15	Open Park environment and Safari wild animal spot view entertaining and educative, pollution of wild animal wallowing pond (odours emitted).	Effects 1, 2 and 3 above all apply
Japan	5	3	8	1	7	A few language barriers, Open Park environment and safari wild animal spot view entertaining and educative, pollution of wild animals wallowing pond (odours emitted intermittently).	Effects 1, 2 and 3 above all apply
South Africa	2	4	6	-	6	Open park environment, Safari wild animal spot view entertaining and educative, pollution of wild animal wallowing pond (odours emitted).	Effects 1, 2 and 3 above all apply, a few visitors portray disciplinary problems (violent attitudes at the motels and safari walk sites)

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Switzerland	18	11	7	2	16	Good park museum, Open Park environment, Safari wild animal spot view entertaining and educative, Pollution of wild animal wallowing pond (odours emitted), need to improve upon parking lots at the museum for visitors.	Effects 1, 2 and 3 above all apply
Non-park working Ghanaians	22	14	8	2	20	Park workers give more attention to foreign visitors than locals. Rates at the gate are high. It should be lowered for local visitors. Restrictions are so much for local visitors especially regarding the use of the swimming pool. In fact, many locals have inequitable access to swimming pool facility.	Effects 1, 2 and 3 above all apply, 4. Majority of visitors have disciplinary problems and sometimes disregard instructions during safari walks. A few misconducts at the motel, exhibited in the form of excessive drinking acts. 5. A few tourists litter and make noise (occasionally at the motel, but more rampant at the dormitories). 6. They often ask intriguing and outrageous questions.
Ghanaian Park workers	6	4	2	6	-	-	Problems of adjusting to the divergent needs of visitors satisfactorily. Workers have to always be vigilant, disciplined, look sharp and act promptly. High population of visitors at the park during winter holidays and national public holidays and festive days tend to tighten the work schedules of park staff thereby, creating resource constraints at the motel,

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						mounting excess pressure and increasing pollution levels within the park environs.
Total	75(100%)	70 (100%)	87 (100%)	21 (100%)	92 (100%)	

of foreign visitors (iFV) over the same period. Implicitly, when more foreign visitors are anticipated in a given year, then the number of local visitors may drop and the *vice versa*. Complementary rise in foreign tourist numbers augment carrying capacity deficits while, hosting more local tourists commensurately salvaged annual numerical target deficiencies. There was a lag phase whereby, neither foreign nor local visitors were enumerated at the park. We referred this as the "*critical period*", difficult to strike a ratio (accounting for missed data in 2012-2013, and these portions were highlighted in red colour on Table 1). This critical incident was due to the Ebola upsurge in Africa. Preventive interventions were adopted from the WHO to quarantine Ebola zoonotic cases from wild life adventures and forestall public health (Funk and Piot, 2014).

Mole has the unique optimum potential to deliver on ecotourism services to local and foreign visitors (Kuuder et al., 2013). Thorough diagnoses of different park visitor perceptions identified historic-cultural, environmental, entertainment and other miscellaneous types of site attraction facilities (Chart 1). Early reporters identified satisfaction as vital element for sustainability of ecotourism whilst linking this factor directly to facilities available at the final spotting sites for visitor attraction (Gursoy et al., 2007). Their reason was that perception analysis is vital in helping the tourists decide whether to recommend the destination to others or to revisit (Kazaks and Rimmington, 2000). Measuring satisfaction in tourism has two purposes: providing information about customer needs, and how the organization or product is currently positioned to address these needs (Gursoy, et al., 2003). It generally provides a platform for organizations to communicate with customers and harmonize their likes, dislikes and overall satisfaction (Banyai, 2012). In 2013 for instance, Kuuder and his observant colleagues tracked the nationality of visitors to the Mole park as follows: Americans 25%; Britons 20%; the Dutch 12%; Germans, 5%; the French 4%, Ghanaians 31%; and 'others' which had a percentage each or less and these represented the Swiss, Canadians, Italians and Nigerians respectively. The array of resources outlined in chart 1 suggest that Mole has majority (80–85%) of the required facilities for attainment of full ecotourism values for sustainable national development (Appendix Table 2) (UNEP and UNWTO 2005).

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Analyses of the expectations of visitor attraction to Mole reveal about (57%) majority of non-Ghanaians visit the park to observe holidays while 33% explore the country for. Close to 6% conduct research and 4% accomplish internship work.

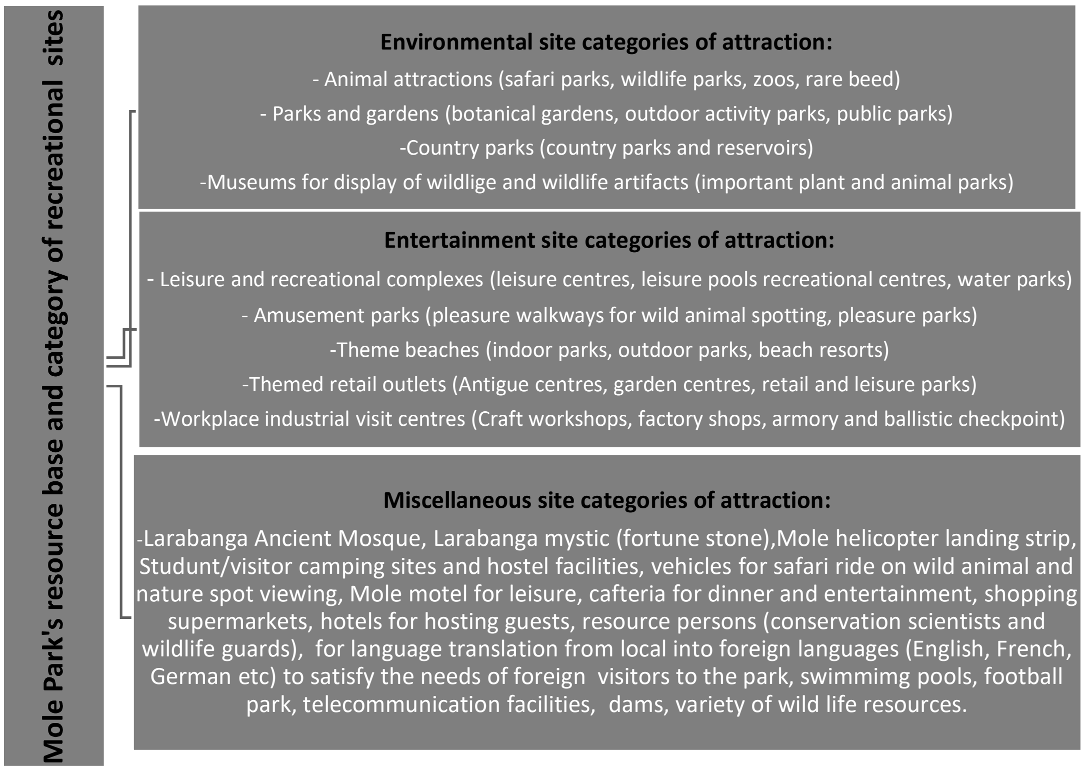

Chart 1: Category of Tourism and Recreational Sites Facilities Within Mole
Sources: Dewhurst, (1996); Kuuder et al., 2013; Revised in 2017 from Field Studies.

About 70 % of the foreign guests got informed about Mole through friends and relatives, 23% from their travel/tour guides and 7% from Ghanaian Missions abroad. Implicitly, word of mouth publicity constituted the most potent tool in attracting more international guests to the facility. The previous survey data unveiled that 42% of foreigners made return day trips to Tamale or elsewhere after visiting the park, 31% passed a night while 17% and 6% respectively spent two to three nights at the Mole Motel while 4% spent about four nights conducting research. Foreigners who made return trips disclosed that limited scenery activities of interest after viewing wild animals was a demerit for derivation of total satisfaction in the long run. All domestic front visitors were day excursionists, though 91% of the foreign visitors were first timers along 9% repeat visitors who generally remarked that park administration staff have enormous task to improve recreational facilities towards attracting and enticing all visitor categories to spend at least a night in the Park (Kuuder et al., 2013).

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Eco-jurisdictional Potential of Mole in Ghana within the Sub-Saharan Africa Region where Ebola Incidence Affect Ecotourism Sustainability

Mole National Park which receives a lot of international excursionists is also exposed to zoonotic risks. The mapped information reveals that large swathes of Central and West Africa appeared to be Ebola free for ecotourism attraction (Figure 4). The dates and locations of outbreaks of Ebola virus disease in humans are shown on the map (Funk and Piot, 2014). Over the last four decades, there have been 23 outbreaks of Ebola in humans across Africa, matching with the period of this study (WHO, 2014; Funk and Piot, 2014). The small circles illustrate locations of the primary infections from past outbreaks on the map (coloured pink or red) according to the dates of upsurge. The outbreak in West Africa started in December 2013 in Guinea pointed with larger black circle. The 2001–2002 outbreak (in asterisk) had primary infections in both Gabon and the Republic of Congo.

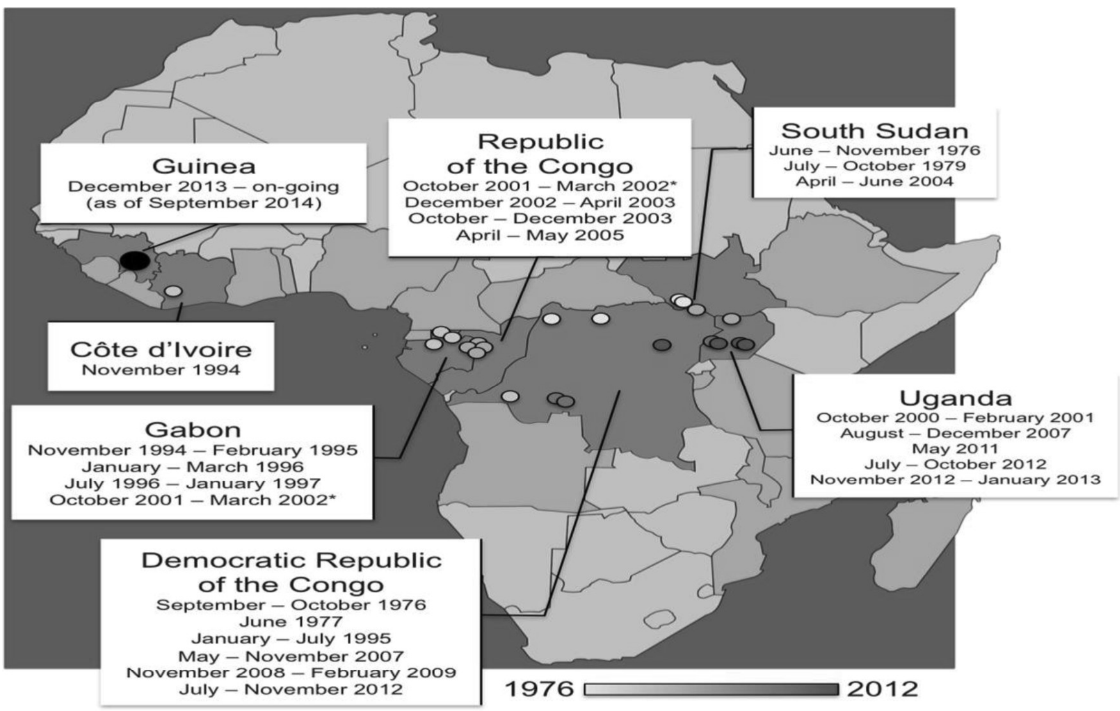

Figure 5: Dates and Locations of Outbreaks of Ebola Virus Disease in Humans

Source (Funk and Piot, 2014)

The 1994 outbreak in Côte d'Ivoire infected one researcher who had handled a dead chimpanzee but later recovered. Piggott et al (2014); have used the catalogued data on previous primary infections, infections in wild animals and climate and vegetation indexes to predict regions where Ebola might be transmissible from non-human animals. There were entirely 22 countries at-risk: seven with previous indexed cases (shaded in red) and 15 others where, cases had not been recorded (shaded in orange) based on prevalence of environmental conditions for Ebola infection in non-human species as of 2014. Further analysis on outbreak in an area deemed to be at risk, was still within 5 kilometres of the village presumed to be the origin of the Ebola outbreak (Walsh *et al.,* 2014). This 'at-risk area' covering some 22 countries was inhabited by 22 million people (WHO, 2014). Not necessarily the size of the population at risk of getting infected with Ebola virus was the key issue; rather, it represented the population that

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lived within the area estimated to be suitable for transmission in animals. The occurrence of Ebola and its human-to-human transmission nature easily spread the virus away from source I countries such as the Democratic Republic of Congo-where most outbreaks occurred (WHO, 2014).

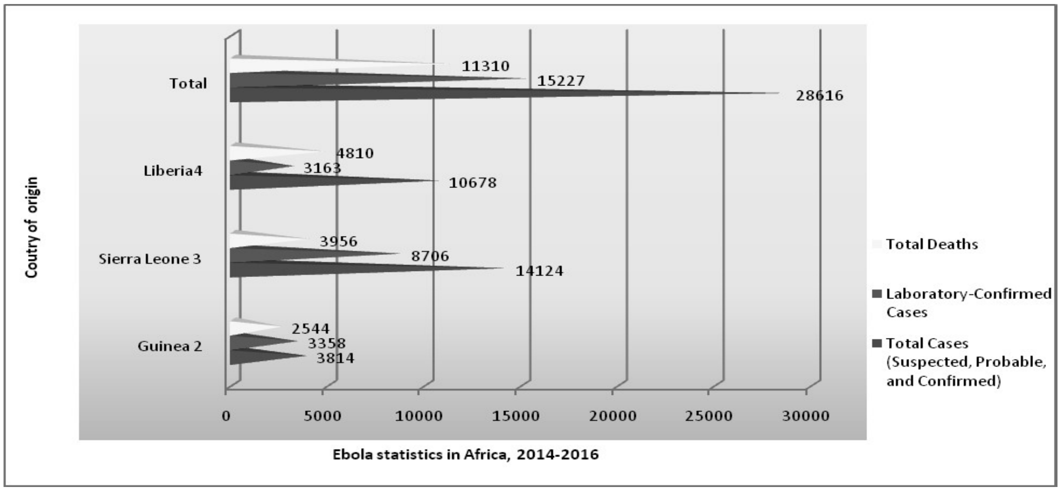

Figure 6: Countries with Former Ebola Widespread Transmission and Current, Established Control Measures[1].

Sources of Data: WHO/CDC, 2016

The previous four decades Ebola primary infections trended by 23 cases of infection among humans across Africa (Piggott *et al.,* 2014). The indexes (1-4) were tagged on the country specific Ebola infection records by the CDC at WHO. The category ([1]) countries experienced widespread transmission but transitioned to be declared free of Ebola (Figure 6).

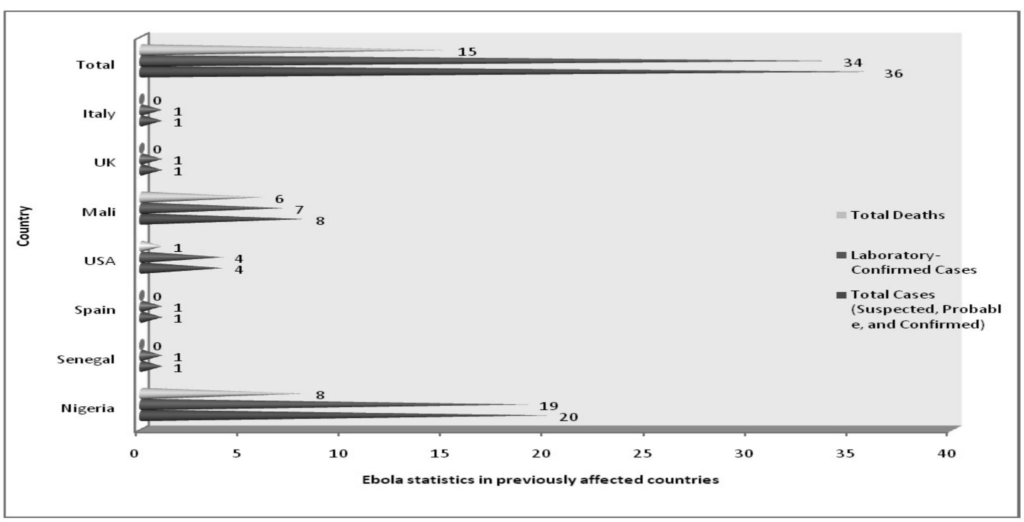

Figure 7: Ebola Statistics in Previously Affected Countries Tagged [5]

Source of Data, WHO/CDC 2016

Public health authorities in these countries effectively mounted surveillance to identify new Ebola cases by locating and monitoring any potential contacts to meet global health

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specifications (CDC, 2014-2016). As of December 29, 2015, the WHO declared Guinea Ebola virus free with tag ([2]) and changed its classification on December 29, 2015, for recognition as a country with former widespread transmission and well-established control measures. Sierra Leone was then declared free of Ebola and tagged ([3]) on November 7, 2015 by WHO after two incubation periods of 42 days had passed since the last Ebola patient tested negative. However, CDC changed the Sierra Leone's classification on November 10, 2015, to a country with former widespread transmission and established control measures when 2 new confirmed cases were discovered in January 2016. But on March 17, 2016, WHO declared an end of the epidemic when the last patient tested negative. WHO first declared Liberia free of Ebola virus transmission on May 9, 2015, tagging the country ([4]) on scale but the country later experienced six incidental clusters of Ebola in June 2015. It was declared free of transmission on September 3, 2015 (Figure 7). The WHO again, declared Liberia free for the third time on January 14, 2016 after successfully dealing with three Ebola cases that were reported in November 2015. The CDC/WHO (2014-2016) analysis focused on outbreak climate factors as predisposing for Ebola transmission and symptoms, risks of exposure, prevention, diagnosis and treatment with trial vaccines in affected countries. Similar investigations in Ghana points to a narrow escape from any Ebola incidence, since, no valid case was diagnosed or confirmed. This clean record phenomenally elevated Ghana internationally based on its prevalent environmental conditions that suit sustainable ecotourism functions (Osei-Bonsu, 2016; ATM, 2015).

Comparative WHO Guidelines for Water Quality Index Parameters Regulating Recreational and Ecosystem Functions in Mole National Park

Links between persistent environmental conditions of parks and ecosystems sustainability functions/actions attract divergent views for decision making (UNESCO 2017). In operating new interventions, the physicochemical parameters influencing water quality for potential ecosystem functions were analysed for some pollution effects emanating from the conjunctively used water resources in Mole park environs, compared to WHO recreational water quality guidelines (Seegert et al., 2013; Environmental Protection Agency (EPA), 2001). General statistical analyses based on the Related-Samples Friedman's Two-Way Analysis of Variance by Ranks among the recorded values of Turbidity (NTU), pH, Temperature (°C), EC (µS/cm), TDS (mg/L), Total hardness (mg/L), Alkalinity (mg/L) were conducted on the raw scientific data obtained from the entire sampled water in the Mole environs. It revealed a unique pattern of highly asymptotic significant (2-sided test) differences (p<0.000) in parametric data, such that, the ranked means in descending orders were: [EC(6.78 µS/cm) > Total alkalinity (6.11mg/L); > TDS (4.61mg/L); > Turbidity (3.33mg/L); > Temperature (2.28°C); > pH(1.220] in the entire water sources (Appendix Figure 1).

Turbidity

Metcalf and Eddy (2003) stated that colloidal materials such as clay, silt, rock fragments and metal oxides from the soil affect the scattering or absorption of light and thus preventing its transmission in water bodies. Turbidity of the seven water bodies ranged (1.27 NTU - 57.4) NTU with none of the figures above the EPA guideline value of 75 NTU (Figure 8). The site-by-site partial and Pearson's correlations analysis of the entire water sites revealed highly significant differences amongst them (p<0.00 at 1-tailed partial) compared with temperature and pH constants. Pearson's correlation was only significant between Turbidity and pH (p<0.023) of entire sites (Appendix Tables 3 and 4). However, turbidity and other parameters (EC, TDS, Total hardness and Alkalinity) were not significantly correlated as the (p-values were > 0.05, at 1-tailed). An independent-sample Kruskal-Wallis test across the sites did not

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also show any asymptotic significance (2-tailed) in validated turbidity values across the various water sites ($p \geq 0.433$) (Appendix Table 5).

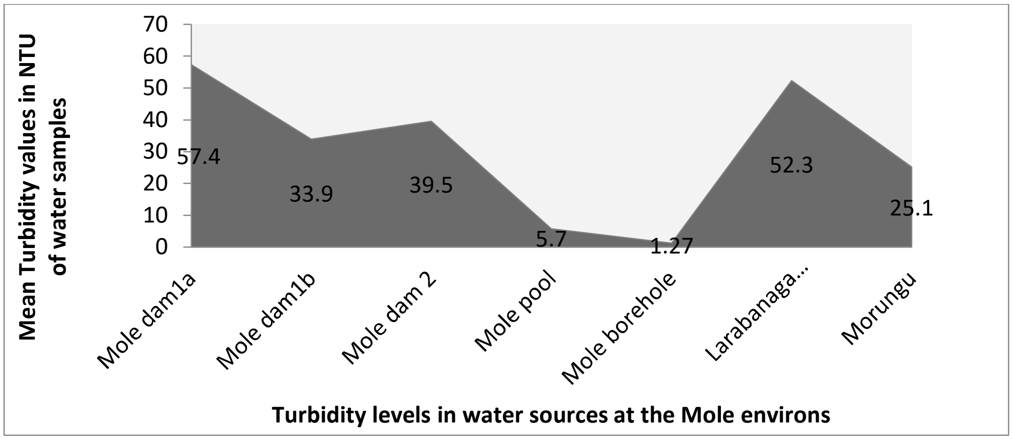

Figure 8: Turbidity Levels in Water Sources at the Mole Park Environs

Significantly higher transparency of the water bodies may be attributed to low amount of silt and nutrients that stimulate cyanobacteria and algal growths (WHO, 2006). Mole borehole depicted the lowest turbidity (1.27 NTU), opposed to the highest record at Mole Dam 1a (57.4 NTU). Highest turbidity value in Mole Dam 1a may be due to entanglement with waste discharge runoffs from adjacent watersheds (especially those affected by erosion) and their fossilized biomass decays. These effects were earlier deduced in previous publication of Metcalf and Eddy (2003).

*p*H

Detective *p*H of both the groundwater and surface water bodies was relatively stable compared to the EPA guideline value of 6-9 for recreational functions at Mole.

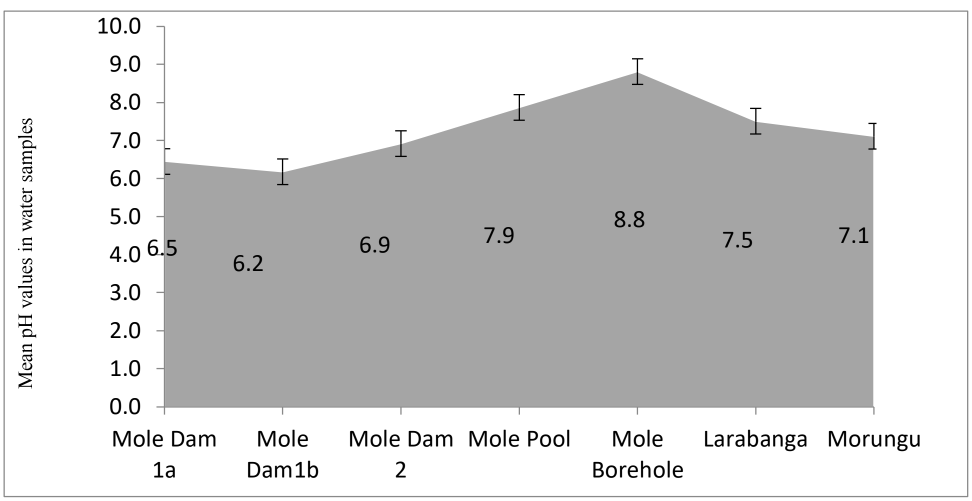

Figure 9: pH Levels in Water Sources at the Mole Park Environs

The *p*H of Mole dam 1a (6.5), Mole dam 1b (6.2) and Mole dam 2 (6.9) were lower than other understudied sites. Only Mole borehole *p*H of 8.8 slightly exceeded the WHO maximum

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guideline (6.5-8.5mg/L) for drinking water quality acceptance (Figure 9). Using *p*H as a constant for partial correlation analyses, revealed significant differences (1-tailed) between the *p*H and turbidity, TDS and alkalinity of the water sites ($p<0.00$; $p<0.034$ and $p<0.003$) respectively, whilst the Pearson's correlation analyses also revealed significant differences (at 1- tailed) between *p*H and [Temperature ($p<.018$); EC ($p<0.006$), alkalinity ($p<0.002$)] of various water sites (Appendix Tables 3 and 4). An independent-sample Kruskal-Wallis test across the sites did not confirm any asymptotic significance (2-tailed) in validated *p*H values ($p \geq 0.433$) (Appendix Table 6). The United State Geological Survey (USGS, 2002) intimated, high or low *p*H will adversely affect the availability of certain chemicals or nutrients in the water for use by planktons apart from influencing metabolic activities among swimmers in recreational waters. The *p*H of water is a very important target parameter because it controls many metabolic reactions in microbial cells such as energy generation and ion transport (Awuah, 2006). Studies on the effect of *p*H on disinfection by-products in swimming pool water which investigated the formation and predicted the toxicity of different groups of disinfection by-products from human exudes in relation to chlorination of pool water at different *p*H values ($6.0 \leq p\text{H} \leq 8.0$) signalled genotoxicity and cytotoxicity of the chlorinated human exudates (Hansen et al., 2012).

Temperature

Temperature of the seven water bodies differed from each other, ranging between 23.7-27.8°C with the lowest and highest values recorded at Larabanga and Mole boreholes respectively (Figure 10).

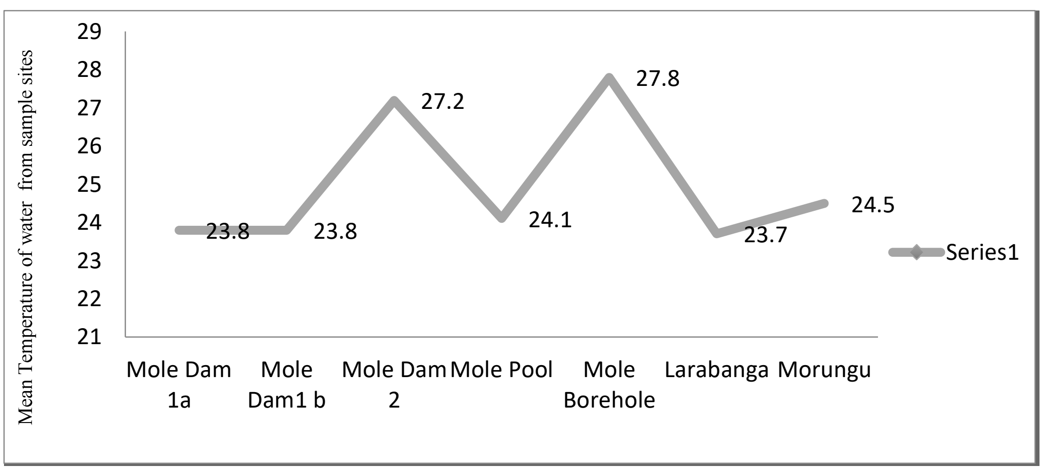

Figure 10: Temperature Levels in Water Sources at the Mole Park Environs

The partial correlation analyses with other parameters revealed significant differences (1-tailed) between temperature and turbidity, TDS and alkalinity of the water site ($p<0.00$; $p<0.034$ and $p<0.003$) respectively. Pearson's correlation analyses showed significant differences (at 1-tailed) between Temperature and [*p*H($p<.018$); Total alkalinity ($p<0.032$)] (Appendix Tables 3 and 4). Similarly, independent-sample Kruskal-Wallis test across the sites failed to confirm asymptotic significance (2-tailed) in validated Temperatur*e* values across the sites ($p \geq 0.433$) (Appendix Table 7). Suitable swimming pool temperature can enhance swimmer's comfort and enjoyment for pool adventures, save on energy used for heating and operating, and minimize pool cleaning and maintenance efforts (Ryczkowski, 2017). Pool water temperatures generally range from 26 °C to 28 °C, although there are exceptions to this

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rule in recommendations for the elderly, in therapeutic applications and for other swimmers (Matt, 2020). Further, ASHRAE recommends that recreational pools be kept between 25.6 and 27.6°C (Ryczkowski, 2017). The USGS (2002) alerts that most physical, biological and chemical characteristics of surface waters are regulated under fluctuating temperatures, in the natural ecosystems (Minns et al., 2017). Pankow (1991) earlier noticed temperature of water trickles changes on: the volume of dissolved oxygen (DO) held by contending that ability to retain DO decreases at rising water temperature. Eventually, the rate of photosynthesis by aquatic plants, metabolic rates of aquatic organisms and the sensitivity of organisms to pollution concurrently assume differentiation under temperature fluctuations (Kratochvil and Pollirer, 2017). Higher temperatures also alter feeding habits of aquatic species, increase water requirements in wild animals wallowing and drinking ponds and reverse the sexes of fries and surviving fingerlings in receiving water bodies within reserves (Hunt et al., 2016).

Electrical Conductivity (EC)

The EC values of the entire water sites ranged from 47.6 - 2181µS/cm with most of them depicting levels below the Ghana EPA guideline value (1,500 µS/cm) for recreational functions. Mole dam 1b tended the least value of 47.6µS/cm while Mole pool manifested the highest (2181µS/cm) (Figure 11).

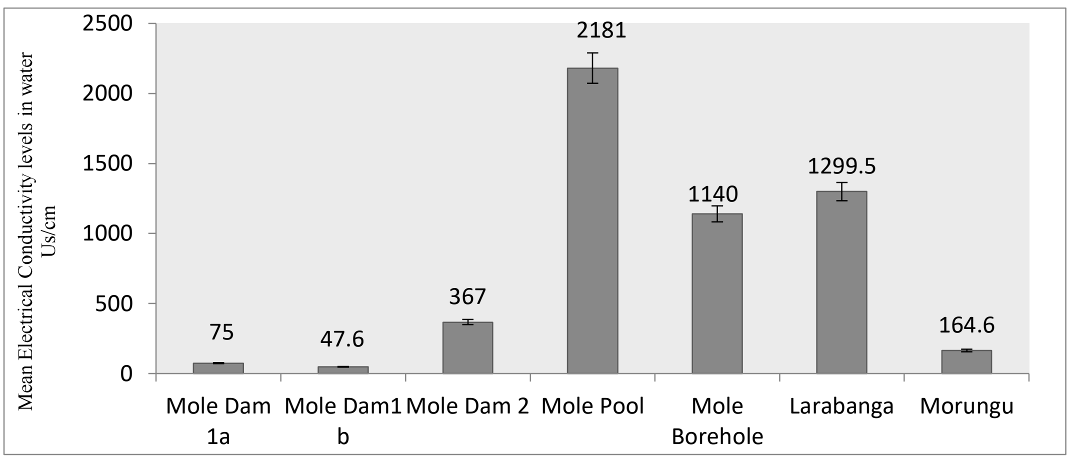

Figure 11: Electrical Conductivity Levels in Water Sources at Mole Park Environs

A site-by-site partial correlation analysis of the EC values between all sites proved highly significant correlation amongst sites ($p<0.00$ at 1-tailed) compared with temperature and *p*H constants and the other parameters. Pearson's correlation was also significantly negative between EC and turbidity ($p<-0.026$) of entire sites (Appendix Tables 3 and 4). But differences between EC and (*p*H, Temperature, TDS, Total hardness and Alkalinity) were not significantly correlated (at 1-tailed) as the (*p*-values were > 0.05). Further independent-sample Kruskal-Wallis test across the samples mean data did not prove asymptotically significant (2-tailed) in validated EC values ($p \geq 0.433$) (Appendix Table 8). The low EC (47.6µS/cm) in water sites could be linked to infinitesimal concentration of dissolved solids in the water. In aquatic studies, low values of EC are depictive of low nutrient waters whiles high values typify salinity problems and *vice-versa* (Dušanka et al., 2013). Fluctuating water EC is most often triggered by unstable temperature and the presence of inorganic dissolved solids such as chloride, nitrate, sulphate, phosphate anions, sodium, magnesium, calcium, iron, and aluminium cations (Spellman, 2003). Electrical conductivity determines dissolved ionic matter state of water, its light and

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electrophilic transmissibility, and circulation of currents in swimming waters which undergo natural purification (Awuah, 2006).

Total Dissolved Solids (TDS)

Solids contained in the water that passes through a filter with a nominal pore size of 2.0um or less are classified as total dissolved solids (TDS) (Hillie and Hlophe, 2012). The TDS of the water bodies differed (Figure 12). The value of Mole Dam 1a (37.4mg/L), Mole Dam 1b (23.8mg/L) and Morungu (28.6mg/L) conformed to the Ghana EPA guideline value of 100mg/L. But the TDS levels were above the EPA guideline in Mole Dam 2 (184mg/l), Mole Pool (109.2mg/l), Mole Borehole (572mg/l) and Larabanga (141.6mg/L) respectively.

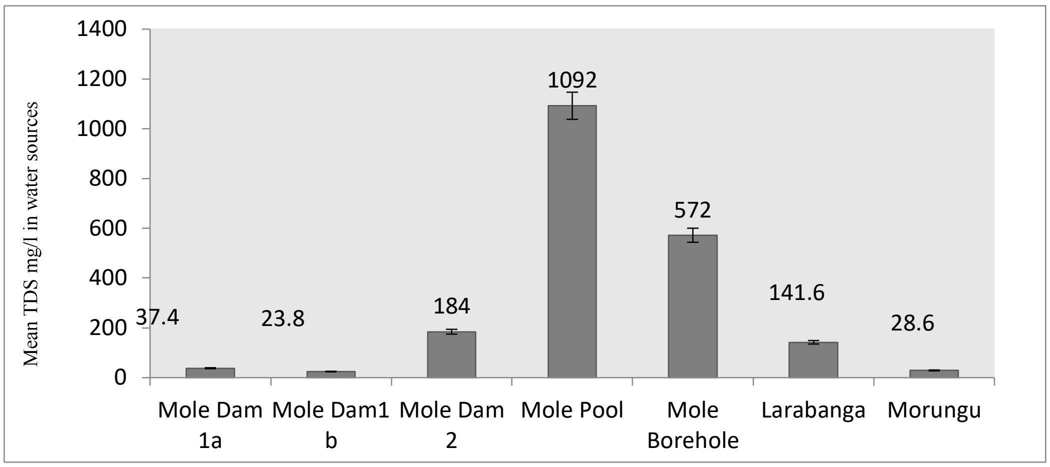

Figure 12: Total Dissolved Solid Levels in Water Sources Mole Park Environs

Site-by-site partial correlation analysis of TDS in the entire water sites proved highly significant correlation (at 1-tailed) amongst them ($p<0.00$) in spite of the significant positive correlation it exhibited with alkalinity ($p<0.027$). The partial correlation of TDS compared with turbidity, EC and total hardness levels were not significant (all p-values > 0.05). Pearson's correlation was however significant (at 1-tailed) but negative between TDS and temperature ($p<-0.015$) of entire sites (Appendix Tables 3 and 4). Pearson's correlations between TDS and Turbidity, *p*H, EC, Total hardness and Alkalinity, were not significant (at 1- tailed) as the (p-values were > 0.05). Independent-sample Kruskal-Wallis test across the mean data did not also prove asymptotic significance (2-tailed) in validated TDS values ($p \geq 0.433$) (Appendix Table 9). Higher TDS values are attributable to the traces of colloidal and dissolved solids as well as smaller particle sizes in the water samples analysed (Hassinger et al., 1994). TDS - is a measure of the combined total of organic and inorganic substances contained in a liquid. This includes anything present in water other than the pure H_20 molecules. These solids are primarily minerals in the forms of heavy metals, salts, pharmaceutical drugs, volatile organic compounds, organic matter, bacteria and viruses, dispersed molecules of springs, lakes and water falls (Berkey 2000). For instance, the water in the Prairie provinces of USA tends to have high levels of TDS due to of high amounts of calcium and magnesium in the ground (Hassinger et al., 1994). Many developed countries specify up to 150-500mg/L TDS as acceptable range for drinking or recreational purposes, although higher TDS in water is one of the leading causes of turbidity and sediments in drinking water; and when left unfiltered, contributes to various diseases (Singh, 2017; Health Canada 2012). Water conductivity increases as the temperature

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increases with corresponding rise in TDS concentration, imparting greater hardness on the water and increasing treatment cost. For each 1°C increment, conductivity of water rises by 2–4% (Woodard, 2019; WHO, 2010).

Total Hardness

Hardness is a natural characteristic of water which can enhance its palatability and consumer acceptability for drinking purposes (Seegert el al., 2014). Total Hardness is the results of direct measurement (principally of calcium and magnesium) expressed as mg/L $CaCO_3$ (Figure 13). Hardness of the water sites ranged from 32.03-124.72 mg/L as $CaCO_3$. None of the water bodies was soft since they were all above 0-30 mg/L as $CaCO_3$ indicated by Ghana EPA Guide. About four of the water bodies comprising Mole dam 1a (31.43mg/L), Mole dam 1b (32.03mg/L), Mole dam 2 (32.03mg/L) and Mole borehole 48.048 mg/L were moderately soft since it depicted TH of 30-60 mg/L as $CaCO_3$ which fell within the Ghana EPA acceptable range. The Morungu (77.47mg/L) and Larabanga (102.1mg/L) water sources moderately exhibited 60-120mg/L $CaCO_3$. Mole pool was hard, due to its 120-180mg/L $CaCO_3$ state of the water. The site-by-site partial correlation analysis of Total hardness in entire sites proved highly significant (at 1-tailed) amongst them ($p<0.00$) compared with the *p*H and temperature. There were no significant partial correlations in total hardness compared with turbidity, EC, TDS and alkalinity of the water sources (all *p*-values > 0.05). Pearson's correlation was significant (at 1-tailed) between total hardness and TDS ($p<0.033$) (Appendix Tables 3 and 4). Pearson's correlation between Total hardness and Turbidity, *p*H, Temperature, EC and Alkalinity were also not significant (at 1- tailed), since the *p*-values were > 0.05. An independent-sample Kruskal-Wallis test across the mean data did not prove asymptotic significance (at 2-tailed) in validated Total hardness values ($p \geq 0.433$) (Appendix Table 10). The main causes of water hardness are dissolved calcium and magnesium (Ca^{2+} and Mg^{2+}) (Howard, 2020). Water hardness is formed when it goes through chalk areas or over limestone and magnesium and calcium ions are dissolved into the water in the reaction process: [$CaCO_3$ (s) + CO_2 (aq) + H_2O (l) = Ca^{2+} (aq) + $2HCO_3^-$(aq)].

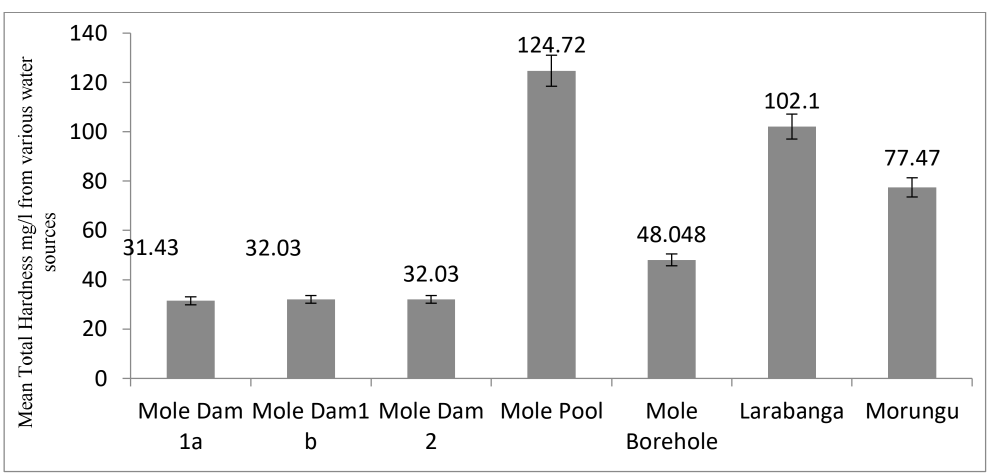

Figure 13: Total Hardness Levels in Water Sources at Mole Park Environs.

Natural waters meant for drinking and recreational purposes are divided into some five groups based on the value of TH: (i) very soft water (0–1.5 mg/L); (ii)soft water (1.5–4 mg/L); (iii) medium hard water (4–8 mg/L); (iv) hard water (8–12 mg/L) and (v) very hard water (more

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than 12 mg/L) (USGS, 2020). Hard water can trigger mineral formation in plumbing, fixtures, water heaters and poor performance of soaps and detergents. Hard water was prevalent in the East-Central and Eastern United States for the distribution of carbonate aquifers with high contents of dissolved solids (USGS, 2020).

Total Alkalinity

Total alkalinity values of the water sites ranged from 55-860mg/L $CaCO_3$. Lowest value (55mg/L) was recorded at Mole dam 1a while the highest (860mg/L) at Mole borehole (Figure 14). Site-by-site partial correlation analysis of Total alkalinity levels in the entire water sources proved highly significant (at 1-tailed) amongst the mean values ($p<0.00$). Partial correlations between total alkalinity and turbidity and total alkalinity and TDS were also significant (1-tailed test) ($p<0.003$ and $p<0.027$) respectively as compared to *p*H and temperature constants.

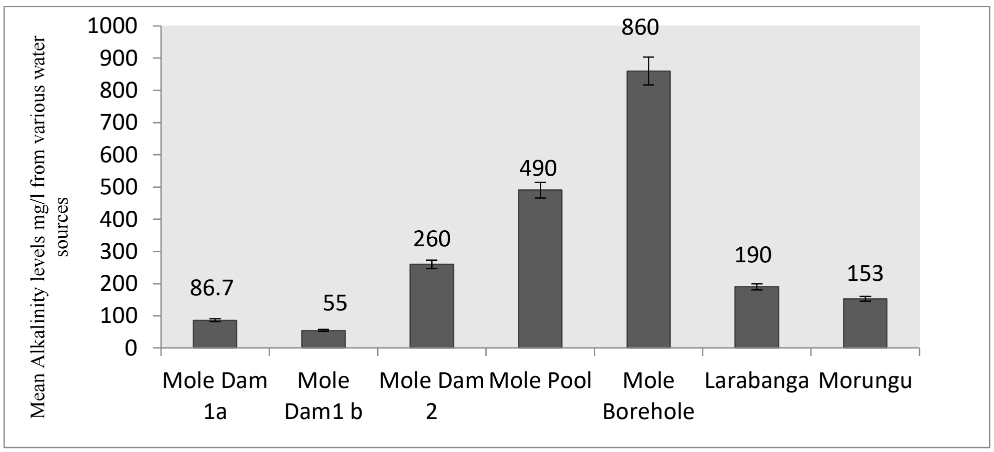

Figure 14 Alkalinity of the Water Sources at Mole Park Environs

There was no significant partial correlation in Total alkalinity level with turbidity, EC and Total hardness (all *p*-values > 0.05). Pearson's correlations were significant (at 1-tailed) between total alkalinity and levels of [pH($p<0.002$), temperature ($p<0.032$), EC($p<0.038$), TDS ($p<0.033$)] in entire water sites (Appendix Tables 3 and 4). Pearson's correlation between Total alkalinity and Turbidity or Total hardness was also not significant (at 1- tailed), (*p*-values > 0.05). Independent-sample Kruskal-Wallis test across the mean data did not prove asymptotic significance (2-tailed) in validated Total alkalinity values ($p\geq0.433$) (Appendix Table 11). Alkaline compounds such as bicarbonates, carbonates, and hydroxides, remove hydrogen ions and lower the acidity of the water thereby increasing *p*H. Alkalinity level is influenced by rocks and soils, salts, certain plant activities at water sheds and industrial wastewater discharges (WHO, 2013).

Conclusions

Tourist perception analysis indicated the great potential of Mole to accommodate more of old and fresh visitors owing to their positive ratings of the park's ecotourism and recreational facilities status. The Ebola risk factor did not constitute a major threat since no case was recorded in Ghana within the study period. This counteracted negative perceptions likely to curtail visiting amateurs even though, their reportages on the environmental conditions called for improvement of cleanliness, adoption of good hygienic behaviours and proper moderation of affordable entrance fees by the Park Management Policy directive or initiative to

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accommodate more visitors since the daily carrying capacities were not exceeded. Laboratory analyses of the water resource quality revealed - turbidity, pH, EC, TDS, TSS and Total Alkalinity values generally fell within the Ghana EPA acceptable standard as compared to the WHO guideline values for promotion of ecotourism functions. Also, the hypothesis test, using Freeman's Two-Way Analysis of variance by ranks showed highly significant differences ($p<0.00$) in the parameters assessed across the water sites. Hence, the Null hypothesis (Ho) that – "distributions of Turbidity, pH, Temperature, EC, TDS, Total hardness and Alkalinity were the same across the water sites at Mole" was rejected. Periodic rainfall figures favoured natural primary productivity functions of the park.

Suggestions Towards Future Research at Mole:

i. Further research should target accurate measurements of water consumption and treatment process in specific human settlement areas within the Mole Park and its buffer zones.
ii. Massive education on best practices should be delivered for conservation of water resources by the Ghana Water Company Limited so as to safeguard water usage.
iii. Some scope of the follow-up study to the present assessment are - micro/macro biological aspects of the water quality on invasive or emerging pathogens of public health significance, emerging contaminants such as antibiotic resistance genes and chemicals (pharmaceutical and personal care products (PPCPs) and endocrine disrupting compounds (EDCs) in these water bodies which may impact and influence recreational functions.
iv. Water Quality analysis after treatment and course of use and during disposal or changing of swimming pool waters may be a significant extension of the studies work. And might later lead to the selection of suitable treatments options when designing new recreational water facilities at the Park.

Suggested Policy Actions to the Government of Ghana (GoG) Towards Sustainable Ecotourism Development at Mole National Park:

i. The Mole National Park Managers should design a detailed methodology and policy strategy for routine comparative quality assurance of the water that is consumed by emergent or existing low-income urban communities within the Park or its buffer zones in microbiological quality aspects. Additionally, the health risks of water contamination by several predisposing factors should be periodically assessed using revised, standard strategic environmental assessment tools to measure the ground effects. This could facilitate development of state-of-the-art park water resource governance policies.

ii. The park management should partner with the Wildlife Division of the Forestry Commission of Ghana and Ministry of Tourism to source funding from Development Partners for further assessment of the water consumption patterns and treatment processes within the park towards the transformation of detailed empirical data on water quality index parameters.

iii. When done with (i and ii above), researchers could then, reliably interpolate the encroaching effects of anthropogenic and other dynamic impacts on the Mole Park. Potential ecological impacts can be determined within the scope and accuracy of assigned strategic environmental assessment tools that can measure real, spatial and

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temporal effects for development of long-term park ecosystem monitoring guidelines or frameworks.

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Ethical Declaration
The research was conducted according to the guiding principles for standard scientific conducts approved under authority of Mole National Park Management Policy Plan. And excluded the handling of any dangerous or invasive wild life species or toxic substances. Provisional statistical data tables and figures are attached as supplementary information which can also be found as pdf file on research gate profile of the main corresponding author.

Conflict of Interest
The authors have jointly agreed to publish this article without any conflict of interest.

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Appendixes

Appendix Table 1: A review of the regional distribution and resource potential of some ecotourism sites in Ghana

Region	Tourism Site	Description	Geographical index	Key resource base	References
Ashanti	Adanwomase Kente weaving	A town in the Ashanti Region of Ghana located in Kwabre East District	About 27 kilometers northeast of Kumasi	It is noted for Kente weaving with towns like Bonwire which is about 2 kilometers away	Donkor, 2015
	Ahwiaa wood carvings	A town in the Kwabre East District	Located 9 kilometers from Kumasi along the Kumasi - Mampong Highway.	Noted for its wood carvings, arts and crafts	*''Ahwiaa". www.ghana.travel. Archived from the original on 2015-09-24. Retrieved 2015-05-25.*
	Bobiri Butterfly Sanctuary	It is a natural reserve rich in biodiversity	It is located on the main Accra - Kumasi Highway at the village of Kubease, about 33.6 km from Kumasi.	Noted for Bobiri Butterfly Sanctuary with more 400 species of butterflies	https://en.wikipedia.org/wiki/Bobiri
	Ntonso Adinkra Arts and crafts village	**Ntonso** is a town in the Kwabre East District of the Ashanti Region	Ntonso, located a few kilometres from Kumasi on the Mampong road in the Kwabre East District	Noted for its Adinkra crafts. It is also the home of Adventist Girls High School.	*ww.ntonso adinkra.com". ntonsoadinkra.webs.com. retrieved 2017-10-03.*
	Bonwire Kente Weaving site	A town in Ejisu-Juaben Municipal district which originated the best and most popular cloth in the whole of Africa. The cloth is popularly known as "Kente"	Bonwire is located 18km on the Kumasi-Mampong Road	Bonwire is also known for the Bonwire Secondary Technical School. The school is a second cycle institution	*Meyer, 2002*
	Lake Bosumtwi	The only natural lake in Ghana, found in the Ashanti region.	Situated within an ancient impact crater that is about 10.5 kilometres (6.5 mi) in diameter. It is about 30 km south-east of Kumasi the capital of Ashanti. About 30 villages surround Lake Bosumtwi, with a combined population of about 70,000 people.	A popular recreational area, according to traditional belief, the souls of the dead come here to bid farewell to the god Asase Ya. Because of this, it is considered permissible to fish in the lake only from wooden planks. Among the fish species in the lake is the endemic cichlid *Hemichromis frempongi*, and the near-endemic cichlids *Tilapia busumana* and *T. discolor*	*Koeberl et al., 2007.*
	Kumasi Zoo	The **Kumasi Zoo** (Kumasi Zoological Garden) is a zoo located in the heart of Kumasi in the Ashanti Region of Ghana	The zoo occupies a 1.5-square-kilometre (370-acre) area between the Kejetia Bus Terminal, the old race course and the Kumasi Centre for National Culture	It has about 40 different species of animals, with individual animals numbering over 135. A notable feature is the thousands of bats that rest on trees in the zoo	Kwame Gyasi, 2014
	Pankrono pottery	A town in the Kwabre East District of the Ashanti Region	Stretches, 8 kilometres on the Kumasi – Mampong Highway located after Tafo.	Noted for its pottery production ventures.	http://www.ghana.travel/touring_ghana/craft_villages/pankrono//2017/10/06
Brong-Ahafo Region	Boaben-Fiema monkey sanctuary	Located about 9 kilometers from Nkoranza and 25Km from Forikrom townships in the Brong Ahafo Region of Ghana	The Sanctuary covers just 1.9 km2 but only parts are truly forested. It is situated in the extreme north of the original forest zone and is currently isolated from any larger forests by some 50 km of derived savanna and farm bus	It has survived only because it provides the essential habitat for two species of monkey that are revered by the local communities. Surveys indicate that the present butterfly fauna is about 375 species, which is impressive for a tiny forest.	Larsen et al., (2014).
	Buoyem	Buoyem is a town in the Brong Ahafo Region of Ghana.	Human population of about 3,900 inhabitants with high population of invasive bats.	The town is known for the Buoyem High School. The school is a second cycle institution. There is high population of bats living in caves,	https://en.wikipedia.org/wiki/Buoyem

				on trees, class rooms ceilings, farms, workplaces etc.	
	Kintampo waterfalls	This is a series of 3 waterfalls, the largest being 25m high. In total, in a number of steps and cascades, the river drops 70m.	In colonial days this was known as Sanders Falls, it is located on the river Pumpum, a tributary of the Black Volta.	On entry a guide takes you first up to the top falls, which can be photographed, then the the centre falls that are difficult to see and finally down to the far larger bottom one. There is a climb of 152 steps back to the car park level. This concrete stairway was added in the mid 1960's. There is an archaeological site at/or near Kintampo, where civilisation can be shown to have existed between 2500BCE and 1400BCE, and it's the earliest known site for the cultivation of the cowpea. These were farmers with stone buildings as wattle and daube, using polished stone axes and stone beads, domestic pots, ceramic sculptures of people and more.	http://www.ghana.photographersresource.com/locations/Landscape/LG/Kintampo_waterfall.htm/2017/10/19
	Bui Dam and Nature Reserve	Ghana's second largest hydroelectric generating station was commissioned by the country's President, John Dramani Mahama, in December 2013. The Bui Power Authority Act 2007 (Act 740) was enacted by the Parliament of Ghana and assented by the President J.A. Kuffour in July 2007 to establish an Authority known as the Bui Power Authority (BPA) whose role was to plan, execute and manage the 400MW project.	Located on the boundary between the Northern and Brong Ahafo Regions.	The Bui hydroelectric project consists of a roller compacted concrete (RCC) gravity dam across the Black Volta and two Saddle Dams on the right bank to contain the reservoir. The RCC dam has a five-bay spillway arranged in the middle and a powerhouse located at the toe on the left bank. The powerhouse has three generating units each with a capacity of 133.3MW. Power produced from the plant is evacuated from the newly constructed Bui Switchyard through 161kV transmission facilities operated as part of the National Interconnected Transmission System. A total of 240km of transmission lines has been built under the project. These include two18km and 17km lines which broke into the existing Sawla-Techiman lines to form Bui-Sawla and Bui-Techiman lines. Other transmission facilities constructed are the 67km Bui-Kintampo line, the 138km Bui-Sunyani line, and expansion of the Sunyani Substation to accommodate the new Bui-Sunyani line.	http://www.waterpowermagazine.com/news/newsbui-dam-project-ghana-4277839/2017/10/19
Central	Kakum National Park	Located in the coastal environs of the Central Region of Ghana. Established in 1931 as a reserve, it was gazette as a national park in 1992 after an initial survey of avifauna was conducted.	Covers an area of 375 Km^2 (145 mi^2)	The area is covered with tropical rainforest. It is one of only 3 locations in Africa with a canopy walkway, which is 350 metres (1,150 ft) long and connects seven tree tops which provides access to the forest. notable endangered species of fauna in the park are Diana monkey, giant bongo antelope, yellow-backed duiker and African elephant. It is also an Important Bird Area	Eagles and McCool, 2013

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				recognized by the Bird Life International with the bird area fully overlapping the park area. The bird inventory confirmed 266 species in the park, including eight species of global conservation concern. One of these species of concern is the white-breasted guinea fowl. Nine species of hornbill and the African grey parrot have been recorded. It is very rich in butterflies as well, and a new species was discovered in 1993. As of 2012, the densest population of forest elephants in Ghana is located in Kakum	
Eastern	Adjeikrom	A Town where Ako-Adjei, considered being one of the "Big Six", who were arguably some of the most famous people in Ghana's fight for independence from British rule hails from.	Adjeikrom is located on the Osiem-Begoro road. From Kumasi or Accra, use the Bunso-Koforidua road and turn left from Osiem. About 10kms to Adjeikrom and Tarred road all the way. Taxis are availablbe from Koforidua or Osiem to Begoro.	Dr. Ako-Adjei was also a founding member of the United Gold Coast Convention, the political party that initially spearheaded the surge for independence. He was born on 17 June 1916 in Adjeikrom, in the Eastern Region of Ghana (then the Gold Coast). Some Quotes of Ako-Adjei: "Ghana is our country. We have nowhere to go. This is where God has placed us and the earlier we realized this the better for all of us."	*Ellison (2002).*
	Akim Abompe	A hub for the stone-bead making industry in the forest zone of Ghana	Akim Abompe is off the main Accra-Kumasi Highway just northeast of Osino. For public transport, minibuses ply from Koforidua to Osino and then taxis from Osino to Abompe.	Preliminary ethnographic observation of the industry not only reveals that it is community-based, but that it also interacts in a complex way with other local crafts in the village which serves as tourist attraction community.	Bredwa-Mensah (1996).
	Boti Waterfall	The Boti Falls is situated in the Yilo Krobo district of the Eastern Region of Ghana. This important waterfall is located at the heart of the forest reserve at Huhunya.	About 17km North-East of Koforidua.	The originating source is from river Ponpon which starts at Ahenkwa-Amalakpo and through to Boti Langmase where it turns into the fall 30m high water falls. Recreational visit has played an important role in the provision of leisure and reduction of stress. Individuals and households pay to enjoy this natural resource that has been provided by nature.	Mohammed (2014)
	Bunso Arboretum	The Plant Genetic Resource Centre is found at Bunso, located	About 1 km away from Lina-door (highway rest stop) at the Koforidua junction where various Ghanaian dishes are served on the Main Accra –Kumasi highway.	Promotes scientific research from an arboretum of different plant species, out of which about 29 species have medicinal value based on ethno-botanical survey of their medicinal uses.	Boateng et al., (2005).
	Akosombo Dam	The Akosombo Hydroelectric Project (Akosombo HEP), usually referred to as the Akosombo Dam, lies in the southeastern part of Ghana.	It is located near Akosombo, a town build mainly for the workers at the dam, early 1960`s	Akosombo has his own run hospital, by Volta River Authority, schools, public swimming pool, market and shops, restaurants, as well as some good hotels and guest houses. Akosombo is also a home of Akosombo Port, with Ferry connection to Northern Ghana,	http://ghananet.com/akosombo-dam.html/2017/10/19

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				and the Dodi-Princess cruise-ship (to Dodi Island)	
Greater Accra	Shai Hills	Located around Dodowa district, closest wildlife park to Accra, only 17 kilometers away compared to Mole National Park and Kakum National Park.	51 square kilometres	The basement consists of stone quarries. Its vegetation is a combination of open and wooded grassland, and fauna found there include guinea fowls, antelopes, baboons and francolins served by a railway station	https://en.wikipedia.org/wiki/Shai_Hills 2017/10/06
	Achimota Forest Reserve	Created in 1930 for research, tourism but has over the years lost more than 150ha as a result of urban infrastructure development and illegal encroachment	Covered 495 ha land areas with vegetation.	An Eco theme park involving the introduction of selected wildlife species and operation of wildlife safaris, an amusement park, eco-lodges, a spiritual enclave and a cultural village.	https://www.ghanaweb.com/GhanaHomePage/features/Achimota-Forest-Major-Ecotourism-destination-43967243/2017/10/06
Northern	Daboya	Capital of the North Gonja District in the Northern Region of Ghana. Daboya is represented by the Damango-Daboya constituency.	Population = 43,547, comprising 49.4% males and 50.6% females, representing 49% and 51% respectively with a growth rate of 2.19%.	'Fugu' smoke weaving and salt mining community. Street lightening procured and installed in Daboya township	North Gonja District Draft Medium Term Development Plan (2014-2017). https://s3.amazonaws.com/ndpcstatic/CACHES/PUBLICATIONS/2016/04/04/NR_North+Gonja_2014-2017+DMTDP.pdf
	Mole National Park	Largest and most prestigious National Park in West Gonja Distict of Ghana	It covers land size of 4,840 km^2	The park centre is endowed with swimming pool, motel and guest houses, viewing centre and museum situated on a hill and surrounded by an escarpment. There are wild animal wallowing pools, and varieties of flora (trees, shrubs, herbaceous plants, grassland and Fauna (over 93 mammal species, and the large mammals of the park include an elephant population, hippos, buffalo, and warthogs. The park is considered a primary African preserve for antelope species including kob, defassa waterbuck, roan, hartebeest, oribi, the bushbuck, and two duikers, the red duiker and yellow-backed duiker. Olive baboons, black-and-white colobus monkeys, the green vervet, and patas monkeys are the known species of monkeys resident in the park. Of the 33 known species of reptiles slender-snouted and dwarf crocodile are found in the park. Sightings of hyenas, lions and leopards are unusual, but these carnivores previously common in the park. Among the 344 listed bird species are the martial eagle, the white-headed and palm-nut vultures, saddle-billed storks, herons, egrets, the Abyssinian roller, the violet turaco, various shrikes and the red-throated bee-eater),trained park guards, vehicles for safari animal spotting, supermarkets, student camp facilities etc.	*Brashares et al., 2001* *Briggs, 2007*

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	Larabanga Mosque	Built in the Sudanese architectural style in the village of Larabanga , Ghana. It is the oldest mosque in the country and one of the oldest in West Africa, and has been referred to as the "Mecca of West Africa". It has undergone restoration several times since it was founded in 1421. The World Monuments Fund (WMF) has contributed substantially to its restoration, and lists it as one of the 100 Most Endangered Sites	Located on the way, about 3 km to the Mole National Park	The mosque has an old Quran, believed by the locals to have been given as a gift from heaven in 1650 to Yidan Barimah Bramah, the Imam at the time, as a result of his prayers. The mosque, built with mud and reeds, has two tall towers in pyramidal shape, one for the mihrab which faces towards Mecca forming the facade on the east and the other as a minaret in the northeast corner. These are buttressed by twelve bulbous shaped structures, which are fitted with timber elements.	Blier, 2013
Upper East	Paga	A small town in Upper East region, lying north of Bolgatanga. Paga is the capital of Kassena Nankana West District, a district in the Upper East region of Ghana. The town is located on the border of Burkina Faso and is 166 km south of Ouagadougou via the N5 highway, the main road linking Ghana and Burkina Faso.	Population of about 10,000 people.	Live crocodile and ponds. Many inhabitants in this small town are multilingual, speaking their native Kasem and English among other languages.	*Ghana Expeditions. 2007-09-07. Retrieved 2011-09-21.*
	Sirigu	a village in the Upper East Region of Ghana. It is about 800 kilometers from Accra.	The village is located 35. Km from Bolgatanga, the capital of the Upper East Regio of Ghana	Well known for its basketry, pottery, traditional architecture and wall painting.	Ghana's Technology City - Africa's Hope For The 21st Century".*www.ghana.gov.gh. March 4, 2013*. Retrieved March 8, 2013.
	Tengzug	Located in the Tongo hills, southeast of Bolgatanga	It is about 17 Km away from Bolgatanga	Tengzug has a Shrine surrounded by hills which is believed to grant luck and prosperity to all those who visit it	https://wikitravel.org/en/Bolgatanga?title=Bolgatanga 2017/10/06
Upper West	Gwollu	It is the district capital of Sissala West in the Upper West Region of Ghana.	A small town 70 km north of Wa.	It is the hometown and birthplace of Ghana's former President Dr Hilla Limann. It was part of the slave route during the slave trade. Gbollu Koro Liman built the Gbollu defence wall in the 19th century as part of its defence against the slavers	*http://touringghana.com/upper-west-region/2017/10/06*
	Wechiau	Wechiau Hippo Sanctuary is a community protected area, located at the extreme north-western corner of the Upper West Region. It is home for aquatic wildlife species.	It stretches 40-kilometres down the length of the Black Volta River, forms the region's western boundary with Burkina Faso	It is home to hippos, bats, chameleons, hedgehogs and many different types of lizards and snakes. The sanctuary is an excellent place to see birds with over 200 species identified and new sights seen regularly. an excellent spot for bird watching, including woodland savannah, riverine and forest shore bird species, monitor lizards, bats, hedgehogs, pythons, and even chameleons.	http://touringghana.com/upper-west-region/2017/10/06
	Gbelle Game Reserve	Is stretches 17 km south of Tumu, the reserve is a sanctuary for indigenous wildlife.	Totally 565km² in size.	Possesses large herds of roan antelope, and is part of Ghana's Conservation Programme.	http://touringghana.com/upper-west-region/2017/10/06
	George Ferguson's Tomb	George Ekem Ferguson was a Ghanaian colonial agent who was instrumental in convincing local chiefs to sign	The Tomb is located at the G.E. Ferguson cemetery in Wa Municipality.	He was later killed in 1897 by slave raiders, but his tomb preserved in Wa.	http://touringghana.com/upper-west-region/2017/10/07

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		treaties of friendship with the British.			
Volta	Amedzofe	Mountainous settlement north of Ho in the mountainous region of the Ho Municipal District of the Volta Region of Ghana. It is presently located in the Newly Created Ho-West District Assembly	It is at an altitude of 677 metres (2,224 feet) above sea level.	Has four natural gifts: The Ote (otay) falls, Mt. Gemi, the Weather and the Landscape. It has played a role in the nineteenth century Anglo-Ashanti Wars. The Amedzofe Training School was built in 1880 by German Missionaries	*The worldwide index of cities and towns. 2007. Retrieved 2007-03-24*
	Kpetoe	A major tourism destination located in Agotime –Ziope District	Population of 34,456. The females constitute about 54.20% whiles the males constitute 45.8%. The most densely populated areas are Kpetoe, Ziope, Afegame and Akpokope. The average household size in these settlements is 4.8%	The rich culture of the District which is displayed during the Agbamevor Za (Kente Festival) of the Agotime People serves as an important attraction for people all over the Country. The Week Long Festival comes in the first week of September and it is devoted to showcase Kente and exhibit varieties of the Agotime Kente.	2010 Population and housing Census, GSS http://www.mofep.gov.gh/sites/default/files/budget/2016/Composite/VR/Agotime.pdf/2017/10/07
	Liati Wote	Nestled in the heart of the Volta Region at the foot of the range of mountains that make up the Ghana/Togo border, Liati Wote is a hidden paradise.	Approximately 885 metres above sea level, (2905 feet)	Liati Wote possesses the highest mountain in Ghana and beautiful water falls (Tagbo Falls), over 300 species of butterflies. Mount Afadjato on a clear day offers views of the neighboring villages, the Tagbo Waterfall, and the Volta Lake	http://www.ghanaexpeditions.com/regions/highlight_detail.asp?rdid=363/2017/10/06
	Kyabobo National Park	The reserve was established in 1997, Located in a transition zone between tropical rain forest and tree savanna.	360-square-kilometre (140 sq mi)	Ghana's second highest mountain, Mount Dzebobo is contained within the park and offers visitors an impressive view of the Lake Volta. Park's wildlife includes African bush elephants, African leopards, African buffalo, waterbuck, several primate species, bushbuck, duikers and, a symbol for the park, the rock hyrax. A park survey lists at least 500 species of butterflies and 235 birds	*Ryman 2013* *Parks and Reserves of Ghana, 2017.*
	Tiafi-Atome	Oral history has it that some 200 years ago, a group of migrants left the coastal shores of Cape Coast in the Central Region of Ghana to their present home in the Volta Region. On arrival, they settled in three major close communities namely Tafi Mando, Tafi Atome, and Tafi Abuise. This ancestral group intercepted a group of calm monkeys who lived amicably with them. The area was organized into monkey sanctuary in 1996 by a Canadian named John Mason who arrived in the community in the mission of scientific conservation research.	Located about 43km South of Hohoe.	Forests area with Fetish monkeys believed to be messengers to the god, the chiefs and people of Tafi communities have been protecting them for the past 200 years.	https://www.newsghana.com.gh/tafi-atome-home-of-monkeys/2017/10/06
	Wli Waterfalls	Wli Waterfalls is the highest waterfall in Ghana and West Africa. It has a lower and an upper fall.	20 km from Hohoe	A walk through the forest of the Agumatsa wildlife sanctuary offers a chance to see a large colony of fruit bats, butterflies, birds, monkeys and baboons. A	"Wli Waterfalls". *www.bridgingdevelopment.org*. Retrieved 2017-04-06.

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				large colony of bats can be seen clinging to the cliffs and flying in the sky	
	Avu-Lagoon	Avu Lagoon in southeastern Ghana is used and owned by 15 Communities, since 1992 it has been recognized as a wetland of international importance under the RAMSAR Convention	The area comprises a 277.67 hectare freshwater lagoon that is 11 km long, up to 5 km wide, and falls within the boundaries of the otherwise predominantly brackish 69,445.42-hectare Anlo-Keta Lagoon Complex	Avu residents, until recently, hunted sitatunga for its meat and hide, but also to fulfil traditional beliefs. Ewe traditional religion is polytheistic, with one supreme deity (Mawu) and many other divine beings associated with particular natural phenomena (e.g.,rain, wildlife), places (e.g., rivers, the lagoon), communities, or family clans	Parrinder, 1961. McPherson et al., 2016.
Western	Ankasa National Park	An area in southwestern Ghana, about 365 kilometers west of Accra near the border with Côte d'Ivoire. It incorporates the Nini Suhien National Park and the Ankasa Resource Reserve.	Approximately 500 square kilometers,	The Ankasa, Nini, and Suhien Rivers all pass through the park, and are known for their rapids and waterfalls. The evergreen rainforest has the most biological diversity of any in Ghana, with over 300 different plant species having been recorded in a single hectare of forest. Animal life includes the elephant, bongo, chimpanzee, Diana monkey, and 263 species of birds. The park includes basic camping facilities with shelters, toilets, and running water along with many facilities for sitting down and having a chat	Ghana Wildlife Society:Ankasa National Park (Accessed October 2017)
	Nzulezu (A village on stilts)	A village in the Jomoro District of the Western Region of Ghana. In 2000, it was nominated as a UNESCO World Heritage Site, and it is a major tourist attraction area.	Nzulezo (or Nzulezu) is located near the village of Beyin, roughly 90 kilometers west of Takoradi,	Nzulezo overlooks the Lake Tadane, and is entirely made up of stilts and platforms. Nzulezo was built over Lake Tadane. The settlement of Nzulezo consists of stilt-supported structures integrated seamlessly with the water-dominated natural landscape. The village can be reached only by a canoe; the route, which crosses the rain forest, takes about an hour to 5 km away. In the village there is a church and a school	Nzulezu Stilt Settlement - UNESCO World Heritage Centre Retrieved on 2017/10/06

Appendix Table 2: Twelve aims to achieve sustainable tourism development

Economic viability	Visitor fulfilment	Physical integrity
Local prosperity	Local control	Biological diversity
Employment quality	Community well-being	Resource efficiency
Social equity	Cultural richness	Environmental purity

Sources: UNEP and UNWTO (2005).

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Statistical data on water quality index parameters in Mole Park

Appendix Table 3: Partial Correlations of water quality index parameters using relatively stable pH and Temperature variables as control for comparison.

Control Variables			Turbidity (NTU)	EC (µS/cm)	TDS (mg/L)	Total hardness (mg/L)	Alkalinity (mg/L)
pH & Temperature (°C)	Turbidity (NTU)	Correlation	1.000	.152	-.720	-.488	-.897
		Significance (1-tailed)	.	.373	.034	.133	.003
		Df	0	5	5	5	5
	EC (µS/cm)	Correlation	.152	1.000	.503	.408	-.111
		Significance (1-tailed)	.373	.	.125	.182	.406
		Df	5	0	5	5	5
	TDS (mg/L)	Correlation	-.720	.503	1.000	.555	.748
		Significance (1-tailed)	.034	.125	.	.098	.027
		Df	5	5	0	5	5
	Total hardness (mg/L)	Correlation	-.488	.408	.555	1.000	.226
		Significance (1-tailed)	.133	.182	.098	.	.313
		Df	5	5	5	0	5
	Alkalinity (mg/L)	Correlation	-.897	-.111	.748	.226	1.000
		Significance (1-tailed)	.003	.406	.027	.313	.
		Df	5	5	5	5	0

Appendix Table 4: Pearson' correlation of water index parameter at Mole Park		Turbidity (NTU)	pH	Temperature (°C)	EC (µS/cm)	TDS (mg/L)	TH (mg/L)	Alkalinity (mg/L)
Turbidity (NTU)	Pearson Correlation	1	.012	.218	-.026	-.677*	-.498	-.417
	Sig. (1-tailed)		.487	.287	.474	.023	.086	.132
	N	9	9	9	9	9	9	9
pH	Pearson Correlation	.012	1	.700*	.784**	.406	.098	.853**
	Sig. (1-tailed)	.487		.018	.006	.139	.401	.002
	N	9	9	9	9	9	9	9
Temperature (°C)	Pearson Correlation	.218	.700*	1	.285	-.015	-.525	.639*
	Sig. (1-tailed)	.287	.018		.228	.485	.073	.032
	N	9	9	9	9	9	9	9
EC (µS/cm)	Pearson Correlation	-.026	.784**	.285	1	.677*	.494	.618*
	Sig. (1-tailed)	.474	.006	.228		.023	.088	.038
	N	9	9	9	9	9	9	9
TDS (mg/L)	Pearson Correlation	-.677*	.406	-.015	.677*	1	.635*	.637*
	Sig. (1-tailed)	.023	.139	.485	.023		.033	.033
	N	9	9	9	9	9	9	9
Total hardness (mg/L)	Pearson Correlation	-.498	.098	-.525	.494	.635*	1	.098
	Sig. (1-tailed)	.086	.401	.073	.088	.033		.401
	N	9	9	9	9	9	9	9
Alkalinity (mg/L)	Pearson Correlation	-.417	.853**	.639*	.618*	.637*	.098	1
	Sig. (1-tailed)	.132	.002	.032	.038	.033	.401	
	N	9	9	9	9	9	9	9

*. Correlation is significant at the 0.05 level (1-tailed).
**. Correlation is significant at the 0.01 level (1-tailed).

Independent-Samples Kruskal-Wallis Test for water quality index parameters at Mole

Turbidity (NTU) across Site

Appendix Table 5 Independent-Samples Kruskal-Wallis Test Summary on Turbidity

Total N	9
Test Statistic	8.000[a,b]
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.433

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a. The test statistic is adjusted for ties.
b. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

pH across Site

Appendix Table 6 Independent-Samples Kruskal Wallis Test Summary for pH

Total N	9
Test Statistic	8.000[a,b]
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.433

a. The test statistic is adjusted for ties.
b. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Temperature (°C) across Site

Appendix Table 7: Independent-Samples Kruskal-Wallis Test Summary for Temperature

Total N	9
Test Statistic	8.000[a,b]
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.433

a. The test statistic is adjusted for ties.
b. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

EC (µS/cm) across Site

Appendix Table 8: Independent-Samples Kruskal-Wallis Test Summary for EC

Total N	9
Test Statistic	8.000[a,b]
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.433

a. The test statistic is adjusted for ties.
b. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

TDS (mg/L) across Site

Appendix table 9 Independent-Samples Kruskal-Wallis Test Summary for TDS

Total N	9
Test Statistic	8.000[a,b]
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.433

a. The test statistic is adjusted for ties.
b. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Total hardness (mg/L) across Site

Appendix Table 10: Independent-Samples Kruskal-Wallis Test Summary for Total hardness

Total N	9
Test Statistic	8.000[a,b]
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.433

a. The test statistic is adjusted for ties.
b. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

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Total Alkalinity (mg/L) across Site

Appendix Table 11: Independent-Samples Kruskal-Wallis Test Summary for Total alkalinity

Total N	9
Test Statistic	8.000[a,b]
Degree of Freedom	8
Asymptotic Sig. (2-sided test)	.433

a. The test statistic is adjusted for ties.
b. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Appendix Table 12: Nonparametric Tests for Related Samples using Friedman's Two-Way Analysis of Variance by Ranks***

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of Turbidity (NTU), pH, Temperature (°C), EC (µS/cm), TDS (mg/L), Total hardness (mg/L) and Alkalinity (mg/L) are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.000	Reject the null hypothesis.

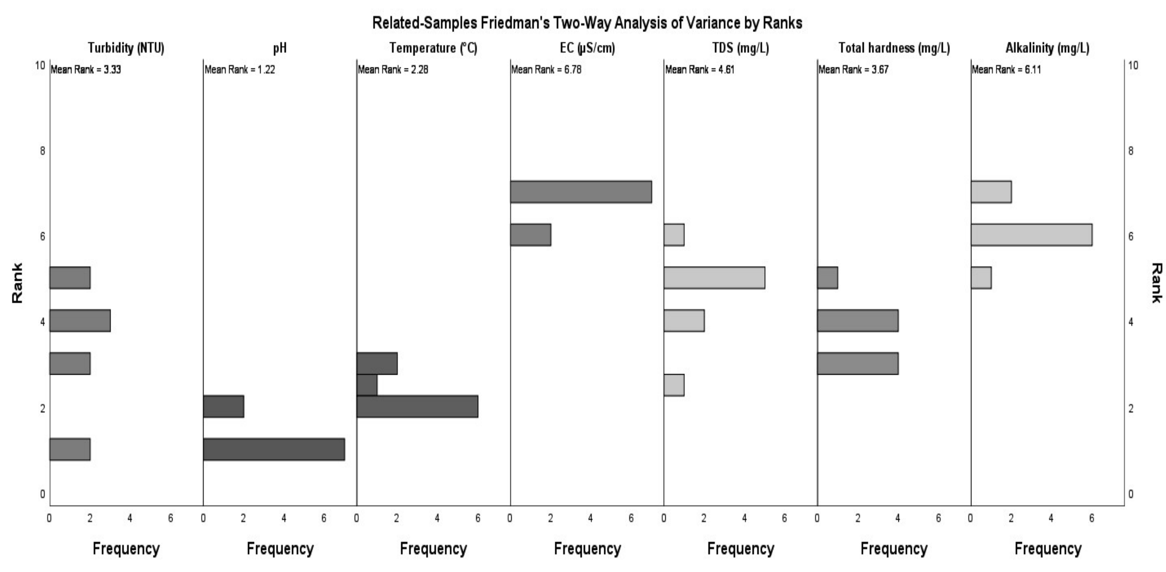
Asymptotic significances are displayed. The significance level is .050.

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks

Turbidity (NTU), pH, Temperature (°C), EC (µS/cm), TDS (mg/L), Total hardness (mg/L), Alkalinity (mg/L)

Appendix Table 13: Related-Samples Friedman's Two-Way Analysis of Variance by Ranks Summary

Total N	9
Test Statistic	45.960
Degree of Freedom	6
Asymptotic Sig. (2-sided test)	.000



Appendix Figure 1: Related Freeman's Two-Way Analysis of Variance by Ranks