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Full Length Research Paper

Microbiological characteristics of waters in the major rivers in Kainji Lake National Park

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This research work determined the microbiological characteristics of the waters of rivers of Kainji Lake National Park. The implications on public health and aquatic life were also examined. The rivers include: Oli, Manyera, Poto and Nuwanzurugi. Samples were taken twice a year, that is, dry and wet seasons of each year. Standard methods were used for bacteriological examination plating. The results revealed high faecal pollution during the wet seasons. This was confirmed by the presence of the coliforms. Isolates include *Pseudomonas spp*. *Escherichia coli*, *Acetobacter spp*, *Maroxalla spp*, *Bacillus spp,* and *Klebsiella spp*. As a result water of the four rivers in the park is not potable during the wet seasons.

Key words: Faecal pollution, bacteriological examination, *E. coli*, *Klebsiella spp*, potability.

INTRODUCTION

Kainji National Park was established in Nigeria by Decree No 46 in 1979. The Park covers an area of 5,830 sq Km. The service provided by the Park include: Wilderness experience, Park viewing, Bird Watching, Lake crushing, Historical/cultural site viewing, Sport fishing and Recreation. The park workers and thousands of farmers inhabiting the park depend on the waters in the rivers for drinking and domestic use. Thousands of tourists also visit the park annually.

Pollution can be defined as the introduction into the environment of substances or energy that is likely to cause harm or hazards for human health or harm living resources thereby causing ecological damage or interfere with legitimate uses of the environment (Okorodudu – Fubara, 1998).

Water quality standards are usually expressed in term of the microbiological, physical and chemical characteristics. Microbiological quality of drinking water is usually expressed in terms of the concentration and frequency of occurrence of particular species of bacteria (Sandy and Richard 1995). According to these authors, polluted water may contain pathogenic bacteria, viruses, protozoa or helminth eggs and the bacteria that are usually involved are usually referred to as “indicator bacteria” (Mossel and Buttaux, 1961). They are usually excreted in large number by worm blooded animals. The presence of the indicator bacteria in the water indicates faecal contamination, Faecal contamination are often linked to the presence of pathogens and thus health hazard (Sandy and Richard, 1995).

The most commonly-used indicator bacteria are the Coliforms. Water is usually tested either for the presence of the total coliform group or for the presence of faecal coliform. This study examined the microbiological characteristics of the water of the four rivers in the Park in order to test for its potability by human population.

METHODS

The study area was Kainji Lake National Park, Nigeria. The research was carried out for a period of two years (24 months). The four rivers were sampled twice a year. That is wet seasons and dry seasons. The rivers include: Oli, Manyera, Poto and Nuwanzurugi. 250ml of river water were collected from each location or sampling point each time for biological examination. Sample bottles were sterilized with Hot Air Oven at 160°C for one hour. The methods of bacteriological examination plating of Miles and Mistra as described by Collins and Lyne (1976) and Singleton (1977) were used.

Fishing sampling were carried out at designated points periodically. Gill nets were set overnight at 18.00 h and the fish were collected in the following morning at 07.00 hours. Fish identification and counting were carried out immediately. Pearson correlation and t-test were used for statistical analysis.

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Table 1. Bacteriological examination of waters in the Rivers in Kainji Lake National Park during dry Seasons 2005.

Sampling point		Total count CFU/ml	Coliform count CFU/ml	Isolates
Code	Name of river			
1. A	River Oli Animal Drinking Point 1	42	3	Pseudomonas spp; E. Coli
2. A	River Oli Animal Drinking Point 2	40	-	Acetobacter spp.
3. A	River Manyera Animal Drinking Point 1	36	-	Klebsiella spp. Acetobacter spp
4. A	River Manyera Animal Drinking Point 2	37	-	Moraxella spp. Acetobacter spp
5. A	River Nuwanzurugi Animal Drinking Point 1	38	-	Moraxella spp.
6. A	River Nuwanzurugi Animal Drinking Point 2	58	-	Bacillus spp.
7. A	River Poto 1	20	3	Pseudomonas spp; E. Coli
8. A	River Poto 2	78	13	Klebsiella spp. Acetobacter spp
9. A	River Oli Hippo Pool Km 8	37	4	Moraxella spp. E. Coli
10. A	River Oli Hippo Pool Km 12	30	-	Pseudomonas sp

Table 2. Bacteriological examination of waters in the Rivers in Kainji Lake National Park during Wet Seasons 2005.

Sampling point		Total count CFU/ml	Coliform count CFU/ml	Isolates
Code	Name of river			
1. B	River Oli Animal Drinking Point 1	290	116	*E. coli*; Acetobacter spp.
2. B	River Oli Animal Drinking Point 2	200	109	Moraxella spp. Klebsiella spp.
3. B	River Manyera Animal Drinking Point 1	230	114	Maroxella spp.
4. B	River Manyera Animal Drinking Point 2	205	102	*E. coli*, Pseudomonia spp
5. B	River Nuwanzurugi Animal Drinking Point 1	20	13	Klebsiella spp. Pseudomonas spp
6. B	River Nuwanzurugi Animal Drinking Point 2	58	25	*E. coli*; Acetobacter spp.
7. B	River Poto 1	80	6	Moraxella spp. Klebsiella spp.
8. B	River Poto 2	120	80	*E. coli*, Pseudomonia spp and Maroxella spp.
9. B	River Oli Hippo Pool Km 8	186	81	Pseudomonia spp. *E. coli*
10. B	River Oli Hippo Pool Km 12	160	40	Acetobacter spp. Klebsiella spp

RESULTS

Table 1 shows the results of bacteriological examination of river waters in the park during the dry season (2005). The total bacteria count range between 20 and 78 cfu/ml while the coliform counts ranged between 3 and 13 cfu/ml. The minimum total bacteria count was recorded at River Poto's sampling point no 1 while the maximum was recorded in River Poto's sampling point no 2. The minimum coliform count was recorded at River Oli Animal drinking point no 1 and River Poto's sampling point no 1. The highest coliform count was recorded at River Poto's sampling point no 2. During the dry seasons 2005, there were no coliform at River Oli animal drinking point (2), River Manyera, River Nuwanzurugi and River Oli's Hippo Pool (km 2), respectively. Isolates included *Pseudomonas spp*, *E. coli*, *Acetobacter spp*, *Bacillus spp* and *Klebsiella spp*. Table 2 shows the results of bacteriological examination of rivers in the park during the wet season 2005. The total bacteria count ranged between 20 and 290 cfu/ml while the coliform counts ranges between 6 and 116 cfu/ml. The minimum total bacteria count was recorded at River Manyera, while the maximum or the highest was recorded in River Oli animal-drinking point no 1. The minimum coliform count was recorded at River Poto's sampling point no 1 while the highest was recorded at River Oli animal-drinking point no 1. Isolates included *Pseudomonas spp*, *E. coli*, *Acetobacter spp*, *Maroxella spp* and *Klebsiella spp*. Table 3 shows the results of bacteriological examination of aquatic media in the park during the dry season 2006. The minimum total bacteria count was recorded at River Nuwanzurugi, while the maximum was recorded in River Oli Hippo pool (km 8). Isolates included *Pseudomonas spp*, *E. coli*, *Acetobacter spp*, *Maroxella spp Bacillus spp*, coagulase positive and *Staphylococcus spp*. There were no coliforms in the five rivers during the dry season 2006. Table 4 shows the results of bacteriological examination of the rivers in the park during the rainy seasons 2006. The total bacteria count range between 28 and 260 cfu/ml while the coliform counts ranges between 15 and 120 cfu/ml. Isolates included *Pseudomonas spp*, *E. coli*, *Acetobacter spp*, *Maroxella spp*, *Bacillus spp* and *Klebsiella spp*.

Table 3. Bacteriological examination of waters in the Rivers in Kainji Lake National Park during dry Seasons 2006.

Sampling point		Total count CFU/ml	Coliform count CFU/ml	Isolates
Code	Name of river			
1. C	River Oli Animal Drinking Point 1	101	-	Moraxella spp
2. C	River Oli Animal Drinking Point 2	141	-	Pseudomonas spp
3. C	River Manyera Animal Drinking Point 1	130	-	Pseudomonas spp
4. C	River Manyera Animal Drinking Point 2	61	-	Coagulase positive
5. C	River Nuwanzurugi Animal Drinking Point 1	83	-	Acetobacter spp.
6. C	River Nuwanzurugi Animal Drinking Point 2	84	-	Pseudomonia spp.
7. C	River Poto 1	53	-	1. Bacillus spp. (2 cols) 2. Pseudomonas spp 3. Coagulase positive 4. Staphylococcus spp.
8. C	River Poto 2	82	-	Pseudomonia spp
9. C	River Oli Hippo Pool Km 8	94	-	Pseudomonia spp
10. C	River Oli Hippo Pool Km 12	64	-	Acetobacter spp.

Table 4. Bacteriological examination of waters in the Rivers in Kainji Lake National Park during wet seasons 2006.

Sampling point		Total count CFU/ml	Coliform count CFU/ml	Isolates
Code	Name of river			
1. D	River Oli Animal Drinking Point 1	260	120	*E. Coli*; *Klebsiella* spp *Pseudomonas* spp
2. D	River Oli Animal Drinking Point 2	240	90	*E. Coli*; *Klebsiella* spp *Pseudomonas* spp *Acetobacter* spp. *Moraxella* spp
3. D	River Manyera Animal Drinking Point 1	29	21	
4. D	River Manyera Animal Drinking Point 2	36	23	
5. D	River Nuwanzurugi Animal Drinking Point 1	28	15	*E. Coli*; *Pseudomonas* spp
6. D	River Nuwanzurugi Animal Drinking Point 2	40	30	*E. Coli*; *Pseudomonas* spp
7. D	River Poto 1	100	20	*E. Coli*; *Acetobacter* spp.
8. D	River Poto 2	80	60	*E. Coli*, *Pseudomonia* spp and *Klebsiella* spp.
9.D	River Oli Hippo Pool Km 8	190	80	*Bacillus* spp; *E. Coli* and *Klebsiella* spp.
10.D	River Oli Hippo Pool Km 12	140	70	*E. Coli*; *Pseudomonas* spp *Acetobacter* spp.

Table 5 shows that eighteen species of fish belonging to twelve families were caught: forty-four fishes were caught. Members of chilidae family were most abundant, that is, 18 numbers out of 44. Figures 1, 2, 3 and 4 compared the dry and wet seasons results of bacterio-logical examination. At the end of the rainy seasons in September all the water samples contained coliforms (Tables 2 and 4), suggesting/indicating faecal pollution. By the middle of dry seasons in January, none of the water samples contained coliforms (Table 3). All the fish sampled were free from the common diseases linked to faecal pollution (Onyeanusi 1996 and Bauer 1973).

In the year 2005 the total count in the wet season (mean = 154.9) is significantly and statistically greater than in the dry season (mean = 41.6) ($P < 0.05$). Coliform count of the water of the rivers in the wet season (mean = 68.6) is statistically and significantly greater than in dry season (mean = 2.3) ($P < 0.05$). Total count (CFU/ml) of the rivers waters is statistically and significantly different among the various sampling points ($P < 0.05$). Coliform count (CFU/ml) of the rivers waters is not statistically and significantly different various sampling points ($P>0.05$). Total count (CFU/ml) of the rivers waters is statistically and significantly different among the various sampling locations ($P > 0.05$). Total count is in descending order as River Oli > River Manyera > River Oli Hippo Pool > River Poto > River Nwanzurugi. Coliform count (CFU/ml) is statistically and significantly different among the sampling lo-

Table 5. Checklist of fish species sampled in Kainji Lake National Park.

S/No	Family	Species	Number Caught
1	OSTEOGLOSIDAE	*Heterotis niloticus*	4
2	MORMYRIDAE	*Mormyrops rume*	1
3	GYMNARCHIDAE	*Gymnarchus niloticus*	2
4	CHARACIDAE	*Hydrocynus bravis,.*	1
5	DISTICHODONTIDAE	*Distichodus brevipnnish.*	1
6	HEPSETIDAE	Hepsetus odoe	2
7	CITHARINIDAE	*Citherinus citharusi.*	1
8	CYPRINIDAE	*Labeo psedocaubie.Labeo coubie,*	4
9	BAGRIDAE	*Chyrycichths nigroditatus,.*	3
10	CLARIIDAE	*Claria anguillaris, Heterobrachus longifilis, Heterobranchus bidorsalis*	5
11	CICHLIDAE	*Tilapia niloticus, Tilapia zilli.*	18
12	MOCHOKIDAE	*Monochokus niloticus,*	2
Total			44

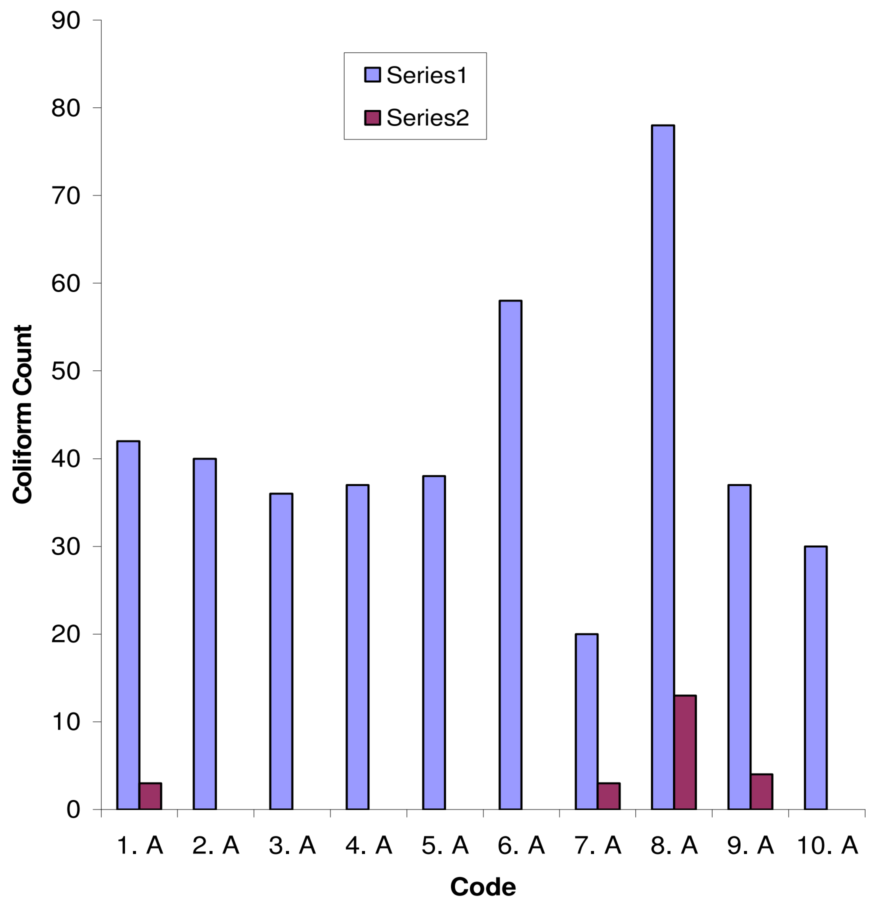

Figure 1. Bacteriological Examination of waters in the Rivers in Kainji Lake National Park during Dry Seasons 2005

cations (P> 0.05). Total count is in descending order as River Oli > River Manyera > River Oli Hippo Pool > River Poto > River Nwanzurugi. In the year 2006 the total count in the wet season (mean = 134.6) is significantly and statistically greater than in the dry season (mean = 65.45) (P < 0.05). Coliform count of the water of the rivers

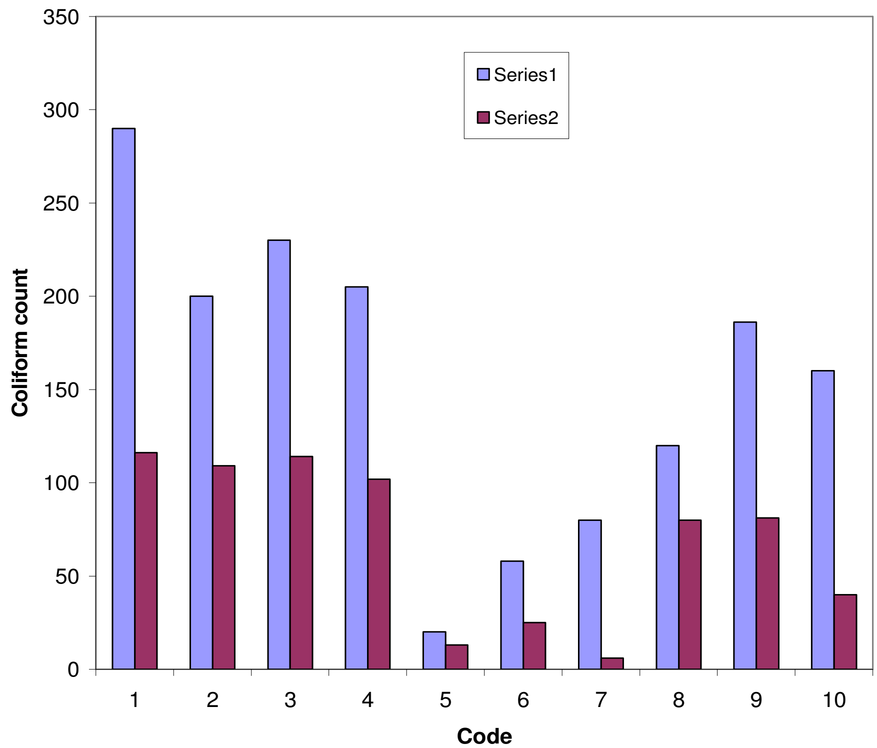

Figure 2. Bacteriological examination of waters in the Rivers in Kainji Lake National Park during Wet Seasons 2005.

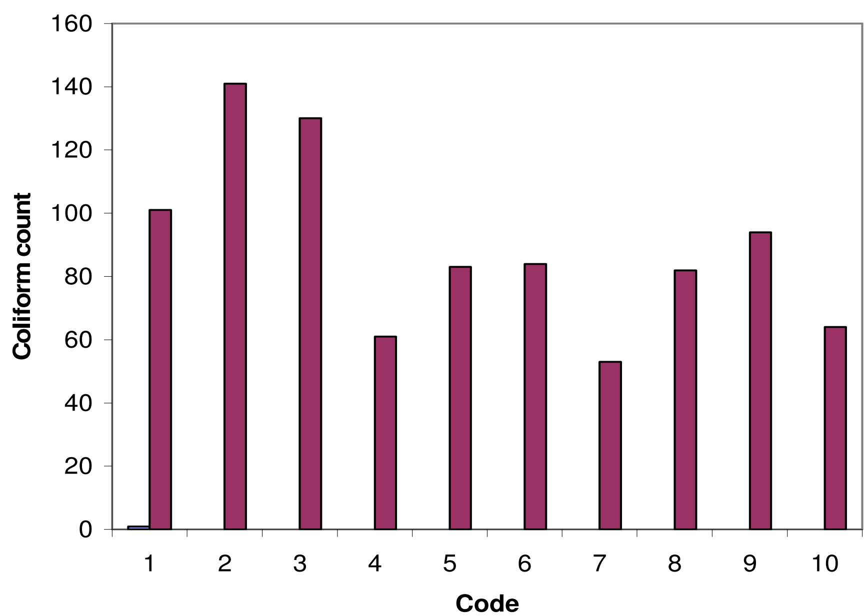

Figure 3. Bacteriological examination of waters in the Rivers in Kainji Lake National Park during dry Seasons 2006.

in the wet season (mean = 60.75) is statistically and significantly greater than in dry season (mean = 1.15) ($P < 0.05$). Total count (CFU/ml) of the rivers waters is statistically and significantly different among the various sampling points ($P > 0.05$). The total count is in the descending order as follows: River Oli drinking point 1 > River Oli drinking point 2 > River Oli Hippo pool Km 8 > River Manyera point 1 > River Oli Hippo pool Km 12 >

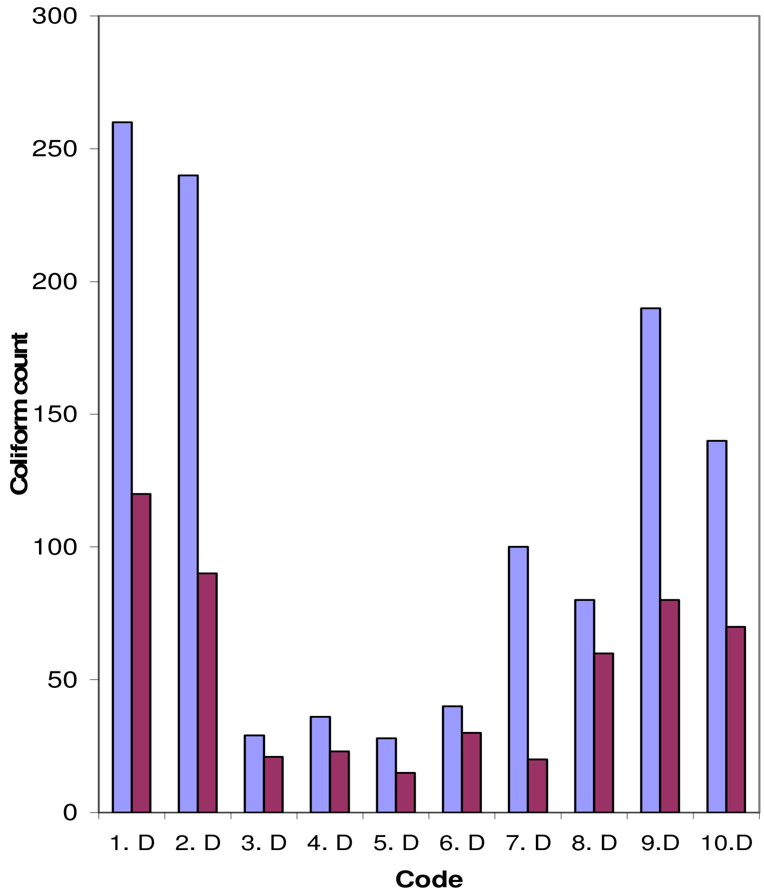

Figure 4. Bacteriological examination of waters in the Rivers in Kainji Lake National Park during wet seasons 2006.

River Poto 2 >River Manyera point 2 >River Poto point 1 > River Nuwanwanzurugi 1. Coliform count (CFU/ml) of the rivers waters is not statistically and significantly different various sampling locations (P>0.05). Coliform count is in descending order as follows: River Oli drinking point 1 > River Oli drinking point 2 > River Oli Hippo pool Km 8 > River Manyera point 1 > River Manyera point 2> River Oli Hippo pool Km 12 > River Nuwanzurugi point 2 > River Poto 1 > River Nuwanwanzurugi 1. Total Coliform count (CFU/ml) is statistically and significantly different among the sampling locations (P> 0.05). Total Coliform count is in descending order as follows: River Oli > River Oli Hippo Pool > River Poto > River Nwanzurugi> River Manyera.

DISCUSSION

Faecal pollution was confirmed by the presence of coliforms in the water samples during the rainy seasons which may arise from animal dungs carried by run-off to the rivers during the rainy season. Mihindu and Oppenheimer (1992) observed that micro-organisms in air and in the soil can have access to the water bodies and contamination may take place either more or less continually or at irregular intervals under certain unusual condition as during or immediately after heavy rains. Sampled fish also contained coliforms but none of them have been associated with any fish diseases. (Bauer, 1973)

The principal coliforms are *Escherichia coli*, *EntErobacter aerogenes*, *Klebsiella spp* and *Citrobacter spp*. *E. coli* is abundant found in the gastro intestinal tracts of humans, birds and animals, but rarely found in water or soil that has not been subjected to faecal pollution. The other bacteria are not also found in the intestine but also elsewhere, therefore their presence in water can indicate faecal contamination. Bacteria composing this indicator group are lactose fermenters and have been recognised as of public health importance for water contamination (Mossel, 1983). The classified indicator for water analysis is *E. coli* and its presence suggests enteric pathogens (Nwadiaro, 1982). There is a direct relationship between the numbers of *E. coli* and the extent of faecal pollution. The higher the number, the more polluted the sample is. This is because *E. coli* cannot multiply in water and therefore, their number slowly declines in river unless new pollution occurs (Akoleowo, 2002). This can explain the absence of coliforms in rivers during the dry seasons when no run-off occurs. According to Bonde (1977), bacteriological examination of water is a powerful and foremost tool in order to foreclose the presence of microorganisms that might constitute a health hazard. Microorganisms that are used commonly as indicator of water include coliforms. Naturally, waters contain a large number and variety of microorganisms which does not necessarily make such water not potable. In fact, the sanitary quality of potable water is determined primarily by the kinds of microorganisms present rather than by the microbial count (Bonde, 1977).

Water source used for drinking or cleaning purpose should not contain any organism of faecal origin (Sabongari, 1982, Fonseca et al., 2000). In that line, The World Health Organization (WHO, 1984) suggested that treated water entering the distribution system should contain no coliform organisms, and tap water should contain no coliform in 95% of samples taken in any one year and it should not contain more than 3 coliforms per 100 ml or any *E. coli*.

However, the question of standards is much more difficult for untreated water supplies of rural people in the tropics,. Untreated water sources are almost invariably contaminated with faecal matter; they contain faecal coliforms and other indicator bacteria. Unfortunately, it is most likely that untreated water from any village in developing country is contaminated by faecal coliforms and other faecal bacteria. Therefore, applying stringent standards would surely condemn the water supplies used by the great majority of the population of most developing countries. At the moment, The World Health Organization does not suggest guideline for untreated or unpiped water supplies that is with less than 10 coliforms and no *E. coli* per 100 ml. Even industrialized countries such as the United Kingdom do not always conform with these standards as many water supplies used by small communities and farms in the upland area in the United Kingdom are contaminated (Sandy and Richard, 1995). It is understood, however, that the World Health Organization will come with more flexible approach in the determination of guidelines for drinking water in the nearest future.

The bacteria loads of water samples during the rainy seasons were very high and likewise coliform counts. As a result we strongly advise not to drink water from those sources during the rainy seasons without treating them. Presence of hippopotamus does not bring about statistically and significant difference in the total count present in the waters of Kainji Lake rivers when examined between River Oli and River Oli Hippo pool (P > 0.05). Also the presence of hippopotamus does not bring about statistically and significant difference in the coliform count present in the waters of the rivers of Kainji Lake when examined between River Oli and other rivers (P > 0.05). This implies that hippopotamus and other wildlife species in the park have almost the same faecal pollution effect in the water of river Oli in this year 2005

Presence of hippopotamus bring about statistically and significant difference in the total count present in the waters of Kainji Lake Rivers when examined between River Oli and River Oli Hippo pool (P < 0.05). Total coliform in the River Oli (mean = 52.2) is greater than other rivers (mean = 37.5). Also, the presence of hippopotamus does not bring about statistically and significant difference in the coliform count present in the waters of the rivers of Kainji Lake when examined between River Oli drinking points and River Oli Hippo pools (P > 0.05). This confirms that the presence of hippopotamus have effect on faecal pollution on the water of River Oli in this year 2006.

Total count (CFU/ml) and coliform count (CFU/ml) are strongly positively correlated (P value < 0.05; r = 0.758) in the wet season, 2005. Also the Total count (CFU/ml) and coliform count (CFU/ml) are strongly positively correlated (P value < 0.05; r = 0.889) in the wet season, 2006.

The beneficial relationship between the hippopotamus and fish have been established. Hippopotamus usually defecate in water and excrements enrich the nutrients in the water, resulting in favourable conditions for large fish populations. Some fish, including labeo spp. were observed to feed on micro-organism and algae that grow on the skin of the hippopotamus (Onyeanusi, 1996).

Pescod (1977) indicated some reported concentrations of faecal coliforms in untreated domestic water sources in developing countries (Appendix I). In Nigeria the National Agency for Food and Drug Administration and Control (NAFDAC) gave a packaged Guidelines for Water Quality Standards for Microbiological Examination adopted from World Health Organization (WHO, 2006) (Appendix II).

Conclusion

Waters in the four rivers in the Park were highly faecal polluted during two wet seasons. As a result the water is not recommended for human consumption. Fish were, however, free from diseases and their pathogens.

Recommendation

Bore holes and wells' waters should be provided for the Park Staff, tourists and the villagers.

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Appendix 1. Drinking water quality some reported concentrations of faecal coliforms in untreated domestic water sources in developing countries.

Source	Escherichia coli per 100 ml[1]
Gambia:	
Open, hand-dug wells, 15-18m deep	Up to 100 000
Indonesia:	
Canals in Central Jakarta	3100-3100 000
Kenya:	
Springs	0
Darn	0-2
Waterhole	11-350
Large river	10-100 000
Lesotho:	
Unprotected springs	900
Waterholes	860
Small dams	260
Streams	5000
Protected springs	200
Tap water (springs)	9
Tap water (boreholes)	1
Nigeria:	
Ponds	1300-1900
Open hand-dug wells,	200-850
Tap water (borehole)	up to 35
Nigeria:	
Ponds	4000 000[2]
Open hand-dug wells	
6-12 m deep	50 000[2]
Stored in home	100[2]
Papua New Guinea:	
Streams	0-10 000
Tanzania:	
Rain water	3
Waterholes	61
Ponds	163
Streams	128
Unprotected springs	20
Protected springs	15
Open wells	343
Protected wells	7
Boreholes	1
Treated tap water	3
Uganda:	
Rivers	500-8000
Streams	2-1000
Unprotected springs	0-2000
Protected springs	0-200
Hand-dug wells	8-200
Boreholes	0-60

a. When only a single value is given it is a geometric mean.
b. Total coliforms rather than faecal coliforms.
These figures are not necessarily typical of the domestic water quality in the countries concerned. They are measurements taken from selected sources during specific investigations. It is generally true, however, that people in developing countries who must use surface sources or open wells are often drinking water with > 1000 faecal coliforms/100 ml (Pescod, 1977)

APPENDIX II

NAFDAC packaged water microbiological examination.

S/N	Parameter/Unit	Standard
1.	Aerobic mesophilic Count cfu/ml	100
	Aerobic mesophilic Count/ml	1 max
2.	Total Coliform MPN/100ml	Nil
3.	E. Coli, MPN/100ml	Nil
4.	Psendomonas /ml	Nil

Source: NAFDAC (2006). Adopted from WHO (2006).

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