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Assessment of Spatio-temporal variation of selected Physico-chemical properties of Kapkatet Wetland, Kericho County, Kenya

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Abstract
Spatio-temporal variation in physico-chemical properties of Kapkatet Wetland was studied. Globally, anthropogenic activities have compromised the integrity of wetlands as far as their sustainability is concerned. Kapkatet wetland is of great importance to the local community and the natural environment. However, it is under threat from anthropogenic activities and climate change effects which has altered its structure and functionality. The study was conducted to investigate the impact of anthropogenic activities on selected water quality parameters and nutrients concentration. Physico-chemical parameters were measured *in situ* using a multimeter parameter probe (model no YS1 15B) at three sampling stations for a period of six months February to July 2019. Nutrient samples were collected in triplicates and analyzed using standard method described in APHA, 1998. Data was analyzed using ANOVA at p = 0.05 to investigate whether there were significant differences among sites and months. Tukey's pairwise comparison was done for any significant difference detected. The spatial results showed the mean DO to be 4.84 ± 0.97 mg/L, pH 5.7 ± 0.61, Temperature 21.26 ± 1.51 °C, NO_3-N 41.6 ± 51.69 µg/L, SRP 364.98 ± 237.87 µg/L and NH_4-N 33.47 ± 31.76 µg/L. Temporal results showed the mean DO to be 4.84 ± 1.07 mg/L, pH 5.7 ± 0.96, temperature 21.26 ± 1.03 °C, NO_3-N 41.61 ± 38.19 µg/L, SRP 33.47 ± 10.43 µg/L and NH_4-N 16.43 ± 6.75 µg/L. These findings confirm that the various anthropogenic activities within the wetland have negative impacts on the Kapkatet wetland water quality. In order to improve water quality in this wetland, proper management of wetland should be done as far as farming activities along the riparian zones, human encroachment and demarcation of the wetland is concerned.

Keywords: Kaptatet wetland, physico-chemical, nutrients, anthropogenic activities

Introduction

A wetland is a diverse ecosystem flooded by waters either seasonally or permanently where oxygen free process prevails and support growth of aquatic vegetation [1]. Wetlands act as buffer zones lying between land and water. Some of their features are low depths, slow moving water with inundated soils, with various forms macrophytes, that is, emerged, submerged, free floating or floating. Globally, wetlands occupy approximately 6% of earth's surface [2]. In Kenya, wetlands occupy about 3% to 4% of the total landmass, which is approximately 14000 km^2. This fluctuates up to 6% during wet season because their distribution mainly depends on amount of rainfall collected at lower basins [3]. Globally, over 50% of land occupied by wetlands have been almost irreversibly degraded due to anthropogenic activities. For instance, in densely populated areas of Europe, North America and East Asia, wetlands have lost more than 80% or brutally degraded of their original land mass area. Therefore, this calls for an urgent need to restore them to their original state through formulation of appropriate management regulations and policies [4]. Wetlands play a crucial role of filtering water naturally through sequestering dissolved nutrients like nitrates and phosphates and further hold suspended solids like silt and particulate organic matter [5]. According to Becht, Odada and Higgins [15], anthropogenic activities like municipal wastes, agricultural practices and vegetation clearance mainly affect water quality. Taylor, Otiang and Oswe [14] further found out that improper disposal of animal and human waste and lack of good agricultural management practices along the riparian zones and directly into wetlands negatively affected the quality of water. Therefore, the main objective of this paper was to assess the trophic state of Kapkatet wetland based on some selected water quality parameters.

Materials and Methods

Study area

Kapkatet wetland is located in Kapkatet Ward, Kericho County, Kenya. It lies at an altitude of 1957 meters above sea level with geographic coordinates of latitudes 0 38'59" S and longitude 35 11'23" E. Three sampling sites were marked based on varied human activities within Kapkatet Wetland. Chepsiyot Sarisari (S1) 00.651195^{0}S 035.208972^{0}E was picked to represent Agricultural activites, Sarisari Midpoint (S2) 00. 650093^{0}S 035. 206038^{0}E representing effecets from padocking and Eucalyptus plantation and Sarisari Daraja Sita (S3) 00.648480^{0}S 035.190458^{0}E representing road construction, car wash and building construction (Figure 1).

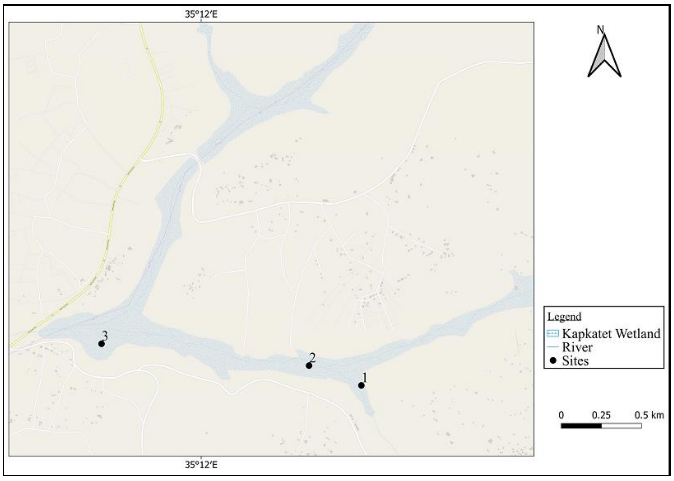

Fig 1: Map of Kaptet wetland showing sampling sites in Kericho County. (1) Sarisari 1, (2) Sarisari 2 and (3) Sarisari 3 (Author).

Data collection and analysis

Measurement of physico-chemical parameters was done *in situ* using a multi parameter meter model number YS1 15B for measuring DO, PH, temperature, conductivity, turbidity, TDS. For nutrients (Total Nitrogen, Nitrates, TSS, Total Phosphate, Silicates, Nitrates, Soluble Reactive phosphates and Ammonia) was analyzed in the KMFRI- Kisumu laboratory. Triplicate samples for nutrient analysis in the laboratory were collected using 500 ml plastic bottles which were thoroughly washed and rinsed with distilled water. They were placed in a cooler box at 4ºC temperature and thereafter transported to the laboratory for analysis. Laboratory nutrient analyses followed the standard methods according to APHA, 1998.

Results and Discussions

Spatial variations of physico-chemical properties

Site S3 showed the highest mean dissolved oxygen of 5.742 mgL^{-1} ± 0.67 SD, followed by S2 with 5.099 mgL^{-1} ± 0.88 SD and S1 showed the lowest mean of dissolved oxygen of 3.664 mgL^{-1} ± 1.35 SD (Table 1). One way ANOVA test showed some significant differences among sampling sites ($F_{(2, 51)}$ = 20.09; p = 0.000). Further, Tukey's pairwise showed that the mean DO of S1 was higher by between 0.63 mgL^{-1} and 2.25 mgL^{-1} than that of S2 and higher by between 1.27 mgL^{-1} and 2.89 mgL^{-1} than that of S3. The mean of S2 was not significant with that of S3. Low DO at site S1 was attributed to decomposition of organic matter and submerged aquatic plants in the water column that consume a lot of oxygen. Site S3 showed the highest mean pH of 6.71 ± 0.44 SD, followed by site S2 with 5.66 ± 1.01 SD and S1 showed the lowest mean pH of 4.72 ± 0.37 SD. The mean pH was statistically significant ($F_{(2, 51)}$ =39.57; p = 0.000). Tukey's pairwise comparison showed some significant differences among sampling sites. The mean pH of S1 was higher by between 0.398 and 1.476 than that S2 and higher by between 1.449 and 2.528 than that of S3. The mean of S2 was higher by between 0.512 and 1.59 than that S3. Low pH of site S3 was attributed to high levels of chemicals like nitrogen and phosphorous fertilizers from the farming activities around the wetland during run off, dissolved wastes from livestock within the wetland. These findings concur with the study done by Mugo [6]. Site S3 showed the highest mean temperature 21.714 ˚C ± 2.25 SD, followed by site S2 with 21.546 ˚C ± 1.44 SD and site S1 showed the least mean temperature of 20.506 ˚C ± 0.85 SD. One way ANOVA test showed that mean temperature was not significant among the sites ($F_{(2, 51)}$ =2.95; p = 0.061). Lowest mean temperature at site S1 was attributed to high vegetation cover and high volume of water that take a longer time to heat. The findings in this study agree with those of Gikuma-Njuru and Hecky [7].

The mean conductivity of site S3 was the highest with 107.09 µScm^{-1} ± 27.72 SD, followed by site S2 with 96.19 µScm^{-1} ± 35.91 SD and site S1 recorded the lowest mean conductivity of 66.19 µScm^{-1} ± 12.64 SD. One way ANOVA test showed that Conductivity was statistically significant ($F_{(2, 51)}$ =10.92; p = 0.000) among sites. The mean conductivity of S1 was higher by between 8.12 µScm^{-1} and 51.82 µScm^{-1} than that of S2 and higher by between 19.05 µScm^{-1} and 62.75 µScm^{-1} than that of S3 but mean conductivity for S2 was not significant with that of S3. The high conductivity in site S3 can be attributed to high organic and inorganic solutes from the eroded organic materials, carwash activities which were observed near the wetland and higher temperatures. These findings concur with that of Ogendi *et al.* [5]. Site S3 showed the highest mean turbidity of 57.4 NTU ± 15.78 SD, followed by mean turbidity of site S2 with 53.62 NTU ± 14.94 SD while S1 showed the lowest mean turbidity of 34.67 NTU ± 16.09 SD. One way ANOVA showed that mean turbidity was significantly different among sites ($F_{(2, 51)}$ =11.93; p = 0.000). The mean turbidity of S1 was higher by between 6.93 NTU and 30.97 NTU than that of S2 and higher by between 10.71 NTU and 34.75 NTU than that of S3. The mean turbidity of S2 was not statistically significant among other sites. The high turbidity of site S3 was attributed to high suspended particulate matter, organic waste deposition and surface run off from the catchment [8]. Site S1 showed the highest mean TSS of 23.03 mgL^{-1} ± 14.12 SD, followed by site S3 with 12.60 mgL^{-1} ± 5.60 SD and site S2 recorded the lowest mean TSS of 10.88 mgL^{-1} ± 9.24 SD. One way ANOVA test showed that the Total Suspended Solids (TSS) was statistically significant ($F_{(2, 51)}$ =7.38; p = 0.002) among sites. The mean TSS of S1 was lower by between 3.90 mgL^{-1} and 20.40 mgL^{-1} than that S2 and lower by between 2.17 mgL^{-1} and 18.67 mgL^{-1} than that of S3. The mean of S2 was not significant with that of S3. High TSS in site was attributed to silt from the nearby farms, decaying of plants and animals waste that were being carried in to the wetland during the rainy season as run off and this findings were in agreement with that of Ogendi *et al.* [5].

Table 1: Spatio variations in physico-chemical parameters (Mean ± SD)

Sites	DO (mgL^{-1})	pH	Temp (°C)	Conductivity (μScm^{-1})	Turbidity (NTU)	TSS (mgL^{-1})
Sarisari 1 (S1)	3.664±1.35	4.72±0.37	20.506±0.85	66.19±12.64	34.67±15.11	23.03±14.12
Sarisari 2 (S2)	5.099±0.88	5.66±1.01	21.546±1.44	96.19±35.91	53.62±14.94	10.88±9.24
Sarisari 3 (S3)	5.742±0.67	6.71±0.44	21.714±2.25	107.09±27.72	57.41±14.82	12.60±5.60
F value	20.09	39.57	2.95	10.92	11.93	7.38
P value	0.000	0.000	0.061	0.000	0.000	0.000

Nitrate and Ammonia Concentrations

Site S1 showed the highest mean nitrate and ammonia concentration of 92.01 μgL^{-1} ± 129.13 SD and 37.28 μgL^{-1} ± 51.17 SD respectively (Table 2). Site S3 showed the lowest mean nitrate nitrogen of 11.79 μgL^{-1} ± 10.83 SD while sample site S2 showed the lowest mean ammonia nitrogen of 28.64 μgL^{-1} ±14.29 SD. One way ANOVA showed that Nitrate nitrogen was statistically significant ($F_{(2, 51)} = 6.93$; $p = 0.002$) among sites. The mean Nitrates of S1 was lower by between 14.13 μgL^{-1} and 127.87 μgL^{-1} than that of S2 and lower by between 23.35 μgL^{-1} and 137.09 μgL^{-1} than that of S3. The mean of nitrate concentration of S2 was not significant with that of S3. One way ANOVA showed that Ammonia nitrogen was not significant among sampled sites ($F_{(2, 51)} = 0.32$; $p = 0.730$). High nitrate and ammonia nitrogen at site S1 and the month of May was attributed to high nutrient concentration at the site, agricultural runoff from the catchment. This study is similar with that of Hubble and Harper [9] where they found out that distribution of organic waste, availability of temperature, macrophytes, dissolved oxygen and the existing of nitrate nitrogen levels.

Table 2: Spatial variation of nutrients parameters (Mean ± SD)

Site	Nitrates μgL^{-1}	Ammonia μgL^{-1}	SRP μgL^{-1}	TN μgL^{-1}	TP μgL^{-1}
Sarisari 1	92.01±129.13	37.28±51.17	21.59±10.81	388.19±266.4	80.51±32.92
Sarisari 2	21.01±15.12	28.64±14.29	11.27±5.68	378.24±260.39	78.59±26.3
Sarisari 3	11.79±10.83	34.49±29.81	16.41±13.91	328.51±186.81	102.6±61.28
F value	6.93	0.32	4.76	0.36	1.97
P value	0.002	0.730	0.013	0.699	0.15

Soluble reactive phosphorous

Site S1 showed the highest mean SRP of 21.59 μgL^{-1} ± 10.81 SD, followed by site S3 with 16.41 μgL^{-1} ± 13.91 SD and the lowest mean SRP was recorded at site S2 with 11.27 μgL^{-1} ± 5.68 SD. One way ANOVA showed that mean SRP concentration was statistically significant ($F_{(2, 51)} = 4.76$; $p = 0.013$) among the sampled sites. The mean SRP concentration of site S1 was lower by between 2.26 μgL^{-1} and 18.39 μgL^{-1} than that of S2 but not significant with that of S3. The mean of S2 was not significant with that of S3. Studies by Sanchez *et al.* [10] found out that high SRP can be attributed to cultural eutrophication from agricultural activities and intense use of land in the catchment through runoffs.

Total nitrogen

Site S3 recorded the highest mean TN of 388.19 μgL^{-1} ±266.4 SD, followed by site S2 with a mean of 378.24 μgL^{-1} ± 260.39 SD and site S3 recorded the least mean of 328.51 μgL^{-1} ± 186.81 SD. Single factor ANOVA showed that mean TN concentration was not significant among sites ($F_{(2, 51)} = 0.36$; $p = 0.699$). Highest mean TN in site S1 was attributed to surface runoff from agricultural activities and domestic effluent at the catchment. This finding corroborates the study done by Sitoki *et al.* [13].

Total phosphorous

Site S3 recorded highest mean TP of 102.6 μgL^{-1} ± 61.28 SD, followed by sample site S1 with a mean of 80.51 μgL^{-1} ± 32.92 SD and site S2 showed the lowest mean TP of 78.59 μgL^{-1} ± 26.3 SD. One way ANOVA showed that the mean TP of sites were not significant ($F_{(2, 51)} = 1.97$; $p = 0.15$). Highest mean TP observed at site S3 was attributed to agricultural fertilizers and domestic effluent that release phosphorous into water column during runoff that has the potential to cause excessive growth of aquatic plants and habitat degradation. This finding corroborates the studies by Trama *et al*., 2009; Ogendi *et al*., 2015 & Chin, 2015.

Temporal variations of physico-chemical parameters

Month of June recorded the highest mean dissolved oxygen of 5.82 mgL^{-1} ± 0.64 SD while the month of July recorded the lowest mean of 3.50 mgL^{-1} ± 1.72 SD (Table 3). Single factor ANOVA showed that dissolved oxygen was statistically significant ($F_{(5, 48)} = 4.28$; $p = 0.003$). Tukey's pairwise comparison showed some significant differences among months. The mean of April was lower by between 0.26 mgL^{-1} and 3.49 mgL^{-1} than that of July but was not significant with that of May and June. The mean DO of June was lower by between 0.70 mgL^{-1} and 3.94 mgL^{-1} than that of July. The mean of May was not significant with other months. Low DO in the month of July was attributed to high rainfall and high a higher concentration of dissolved minerals and nutrients. High concentrations of DO in June can be attributed rapid water movement that causes higher rate of mixing. This corroborates the study by Sitoki *et al.* [13]. The month of March recorded the highest mean pH of 6.34 ± 12 SD while the lowest mean pH was recorded in the month of April with 5.25 ± 0.61 SD. Single factor ANOVA showed that mean pH was not significant among months ($F_{(5, 48)} = 1.92$; $p = 0.11$). Low pH in the month of April was attributed to decomposition of organic matter which releases acidic compounds in the water bodies. The high pH recorded can be attributed to the rocky surfaces with carbonates and hydroxides compounds and this study agrees with that of Ogendi *et al.* [5]. The month of March recorded the highest mean temperature of 22.74 °C ± 1.001 SD while the lowest mean temperature was recorded in July with 18.98 °C ± 1.16 SD. Single factor ANOVA showed that mean temperature was statistically significant among months ($F_{(5, 48)} = 16.58$; $p = 0.000$). Tukey's pairwise comparison showed some significant differences. The mean temperature of February was lower by between 0.771 °C and 3.756 °C than that of June, lower by between 1.835 °C and 4.82 °C than that of July but was not significant with other months. The mean for the month of March was lower by between 1.21°C and 4.195°C than that of June, lower by between 2.27°C and 5.26°C than that of July but was not significant with those of other months. The mean for the month of April was lower by between 0.33 °C and 3.31°C than that of June and lower by between 1.39 °C and 4.38 °C than that of July but not significant among sampled month of May. The mean of May was lower by between 0.065°C and 3.05°C than that of June and lower by between 1.13°C and 4.12°C than that of July. The mean for the month of June was not significant with the month of July. High temperature recorded in the month March was attributed to dry season with low water tables, direct solar radiation, high particulate matter and less vegetation cover in the wetland hence more radiation absorption. The low temperatures recorded in July can be attributed to the wet season with high precipitation rates and more wetland vegetation due to higher nutrients inputs. These findings corroborate with the findings by Zedler and Kercher [2].

Month of April recorded the highest mean conductivity of 129.70 μScm^{-1} ± 45.32 SD while the lowest mean conductivity was recorded in the month of July with 67.12 μScm^{-1} ± 22.46 SD. Single factor ANOVA showed that mean conductivity was statistically significant ($F_{(5, 48)} = 8.48$; $p = 0.000$). Tukey's pairwise comparison showed some significant differences among sampled months. The mean Conductivity of February was lower by between 5.07 μScm^{-1} and 73.41 μScm^{-1} than that of July but was not significant among other sampled months. The mean of March was higher by between 12.51 μScm^{-1} and 80.85 μScm^{-1} than that of April but was not significant among other months. The mean Conductivity for May and June were not significant with other months. High conductivity recorded in the month of April was due to high organic waste and high rate of pollution from various anthropogenic activities being carried near the wetland while the low conductivity recorded in July can be attributed to higher precipitation rates leading to dilution effects. This finding corroborates with the finding by Zedler and Kercher [2]. The month of April recorded the highest mean turbidity of 72.16 NTU ± 14.71 SD while month of July recorded the lowest mean turbidity of 33.23 NTU ± 19.46 SD. Single factor ANOVA showed that mean turbidity was significantly different among months ($F_{(5, 48)} = 11.71$; $p = 0.000$). Tukey's pairwise comparison showed some significant differences among months. The mean turbidity in the month of February was higher by between 0.48 NTU and 35.59 NTU than that of March, higher by between 18.52 NTU and 53.63 NTU than that of April, but was not significant with other months. The mean turbidity in the month of March was higher by between 0.48 NTU and 35.59 NTU than that of April, lower by between 3.33 and 38.44 NTU than that of July but was not significant among other months. The mean turbidity in the month of April was lower by between 2.03 NTU and 37.14 NTU than that of May, lower by between 11.36 NTU and 46.47 NTU than that of June and lower by between 21.37 and 56.48 NTU than that of July. The mean turbidity in the month of May was lower by between 1.79 NTU and 36.89 NTU than that of July but was not significant with that of June. The mean of June was not significant with the month of July. High turbidity in the month of April was attributed to high surface runoff during the rainy season. The month of March recorded the highest mean TSS of 25.00 mgL^{-1} ± 18.87 SD while the lowest mean TSS was recorded in the month of April 8.82 mgL^{-1} ± 2.59 SD. Single factor ANOVA showed that Total Suspended Solids was statistically significant ($F_{(5, 48)} = 3.91$; $p = 0.005$). Tukey's pairwise comparison showed some significant differences among sampled months. The mean TSS in the month of March was lower by between 2.00 mgL^{-1} and 30.36 mgL^{-1} than that of April, lower by between 1.89 mgL^{-1} and 30.24 mgL^{-1} than that of June but was not significant with other sampled months. The mean TSS for the month of February, April, May and June were not significant with other months. The high TSS recorded in this study can be attributed to higher sediments load, silt, and particulate matter hence higher temperatures with low DO while the low TSS recorded can be attributed to reduction in particulate matter on the onset of rainfall. These findings are similar to the findings done by Ogendi *et al.* [5].

Table 3: Temporal variation of physico- chemical parameters

Sites	DO (mgL^{-1})	pH	Temp (°C)	Conductivity (μScm^{-1})	Turbidity (NTU)	TSS (mgL^{-1})
February	4.94 ±1.01	5.79± 0.79	22.30± 1.15	106.36± 26.46	36.08± 7.08	16.91± 9.43
March	4.50± 1.52	6.34± 1.20	22.74± 1.00	83.02± 11.97	54.12± 11.03	25.00± 18.87
April	5.37± 0.51	5.25± 0.61	21.86± 1.46	129.70± 40.32	72.16± 14.71	8.82± 2.59
May	4.88± 1.03	5.27± 1.49	21.60± 0.84	79.23± 10.96	52.57± 52.57	21.16± 7.89
June	5.82 ± 0.64	5.40± 1.00	20.04± 0.57	73.44± 7.18	43.42± 5.43	8.93± 8.62
July	3.50± 1.76	6.13± 0.66	18.98± 1.16	67.12± 22.46	33.23± 19.46	12.20± 5.19
F value	4.28	1.92	16.58	8.48	11.71	3.91
P value	0.003	0.11	0.000	0.000	0.000	0.005

Nitrates and Ammonia concentration

Month of May recorded the highest mean nitrate and ammonia nitrogen of 11.34 μgL^{-1} ± 3.83 SD and 97.85 μgL^{-1} ± 36.41 SD respectively (Table 4). The month of April showed the lowest mean nitrate nitrogen of 9.45 μgL^{-1} ± 7.42 while the month of June showed the lowest mean ammonia nitrogen of 18.52 μgL^{-1} ± 2.94 SD. Single factor ANOVA showed that nitrate concentration was statistically significant ($F_{(5, 48)} = 5.45$; $p = 0.000$) among the sampled months. The mean Nitrate concentration of February was higher by between 39.61 μgL^{-1} and 223.5 μgL^{-1} than that of May but was not significant with those of other sampled months. The mean Nitrate of March was higher by between 37.71 μgL^{-1} and 221.61 μgL^{-1} than that of May but was not significant with those of other sampled months. The Nitrate of April was higher by between 41.51 μgL^{-1} and 225.40 μgL^{-1} than that of May but was not significant with that of June and July. The mean Nitrate of May was lower by between 14.06 μgL^{-1} and 197.95 μgL^{-1} than those of June and lower by between 15.14 μgL^{-1} and 199.04 μgL^{-1} than that of July. The mean Nitrate of June was not significant with that of July. One way ANOVA showed that Ammonia was significant among months ($F_{(5, 48)} = 35.40$; $p = 0.000$). The mean Ammonia concentration for the month of February was higher by between 54.23 μgL^{-1} and

98.84 µgL^{-1} than that of May but was not significant with other months. The mean Ammonia concentration of April was higher by between 51.76 µgL^{-1} and 96.37 µgL^{-1} than that of May but was not significant with other months. The mean Ammonia concentration for the month of May was lower by between 57.03 µgL^{-1} and 101.64 µgL^{-1} than that of June and lower by between 55.06 µgL^{-1} and 99.67 µgL^{-1} than that of July. The mean Ammonia concentration for the month of June was not significant with that of July. The high levels of nitrates and ammonia recorded in the month of May can be attributed to higher surface runoffs that lead to nutrients sedimentation into the wetland from the agricultural catchment while the low concentration of nitrates and ammonia can be attributed dilution effects from precipitation. This corroborates the findings by Mugo [6].

Soluble Reactive Phosphorous (SRP)

The month of March recorded the highest mean SRP of 29.78 µgL^{-1} ± 9.39 SD while April recorded the lowest mean SRP of 3.07 µgL^{-1} ± 1.61 SD. Single factor ANOVA showed that mean SRP concentration was statistically significant ($F_{(5, 48)}$ = 11.90; p = 0.000). Tukey's pairwise comparison showed some significant differences among months. The mean SRP Concentration of February was higher by between 2.804 µgL^{-1} and 23.89 µgL^{-1} than that of March, lower by between 2.81 µg^{-1} and 23.899 µg^{-1} than that of April but was not significant with those of other months. The mean of March was lower by between 16.16 µgL^{-1} and 37.25 µgL^{-1} than that of April, lower by between 5.96 µgL^{-1} and 27.05 µgL^{-1} than that of June and lower by between 2.58 µgL^{-1} and 23.67 µgL^{-1} than that of July but was not significant with that of May. The mean of April was higher by between 5.72 µgL^{-1} and 26.81 µgL^{-1} than that of May, higher by between 3.03 µg^{-1} and 24.12 µg^{-1} than that of July but was not significant with that of June. The mean of May and June was not significant with other months. The high levels of SRP recorded in March can be associated with reduced water levels that lead to higher evaporation rates hence increased SRP concentration levels while low levels of SRP recorded in April can be attributed to dilution effect from precipitation and influxes from surface runoffs.

Total nitrogen (TN)

The month of May recorded the highest mean of TN of 791.34 µgL^{-1} ± 133.39 SD and the lowest mean was recorded in the month of April 121.00 µgL^{-1} ± 70.69 SD. Single factor ANOVA showed that TN concentration was significant ($F_{(5, 48)}$ = 76.26; p = 0.000) among the sampled months. Tukey's pairwise comparison showed some significant differences among months. The mean TN of February was higher by between 32.80 µgL^{-1} and 252.47 µgL^{-1} than that of March, higher by between 417.87 µgL^{-1} and 637.54 µgL^{-1} than that of May but was not significant with other months. The mean of March was higher by between 275.24 µgL^{-1} and 494.90 µgL^{-1} than that of May but was not significant with other sampled months. The mean of April was higher by between 560.51 µgL^{-1} and 780.17 µgL^{-1} than that of May, higher by between 72.99 µgL^{-1} and 292.65 µgL^{-1} than that of June and higher by between 73.00 µgL^{-1} and 292.66 µgL^{-1} than that of July. The mean of May was lower by between 377.68 µgL^{-1} and 597.35 µgL^{-1} than that of June and lower by between 377.67 µgL^{-1} and 597.33 µgL^{-1} than that of July but the mean of June was not significant with that of July. The high levels of TN recorded in the May can be attributed to more run-offs and discharges from streams passing through agricultural based catchment within the wetland while the low levels of TN recorded in April can be attributed to onset of rainfall that led to dilution effect from the rainy season (precipitation).

Table 4: Temporal variation of nutrients parameters (Mean ± SD)

Site	Nitrates µgL^{-1}	Ammonia µgL^{-1}	SRP µgL^{-1}	TN µgL^{-1}	TP µgL^{-1}
February	11.34± 3.83	21.32± 5.71	16.43± 4.0	263.63± 23.00	65.54± 2.61
March	13.24± 0.26	18.85± 2.56	29.78± 9.39	406.26± 108.72	90.14± 11.13
April	9.45± 7.42	23.79± 11.65	3.07± 1.61	121.00± 70.69	40.94± 8.25
May	142.90± 154.28	97.85± 36.46	19.34± 6.0	791.34± 133.39	59.72± 11.95
June	36.89± 32.13	18.52± 2.94	13.28± 11.66	303.81± 32.11	135.34± 29.82
July	35.81± 31.21	20.49± 3.23	16.65± 7.85	303.83± 27.51	131.69± 32.60
F value	5.45	35.40	11.9	76.26	32.60
P value	0.000	0.000	0.000	0.000	0.000

Total phosphorous (TP)

The month of June recorded the highest mean TP of 135.34 µgL^{-1} ± 29.82 SD while the month of April recorded the lowest mean TP of 40.94 µgL^{-1} ± 8.25 SD. One way ANOVA showed that mean TP was statistically significant among months ($F_{(5, 48)}$ = 32.60; p = 0.000). Tukey's pairwise comparison showed some significant differences. The mean TP of February was higher by between 40.99 µgL^{-1} and 98.61 µgL^{-1} than that of June, higher by between 37.34 µgL^{-1} and 94.97 µgL^{-1} than that of July but was not significant with other months. The mean of March was lower by between 20.40 µgL^{-1} and 78.76 µgL^{-1} than that of April, higher by between 1.12 µgL^{-1} and 60.22 µgL^{-1} than that of May, lower by between 15.49 µgL^{-1} and 78.02 µgL^{-1} than that of April, lower by between 1.61 µgL^{-1} and 59.23 µgL^{-1} than that of May, higher by between 16.39 and 74.01 than that of June and lower by between 12.74 and 70.36 than that of July. The mean of April was higher by between 65.59 µgL^{-1} and 123.22 µgL^{-1} than that of June and higher by between 61.95 µgL^{-1} and 119.57 µgL^{-1} than that of July but was not significant with that of May. The mean of May was higher by between 46.81 µgL^{-1} and 104.43 µgL^{-1} than that of June and higher by between 43.16 µg^{-1} and 100.78 µgL^{-1} than that of July. The mean of June was not significant with that of July. The high levels of TP recorded in June can be attributed to high influx into the wetland from stream discharges and surface runoffs from the catchment during the wet season. This corroborates the findings by Mugo [6] and Sitoki *et al*. [13].

Conclusion and Recommendation

From the results, it is evident that the water quality of Kapkatet wetland is affected by anthropogenic activities. It is therefore recommended that proper management of wetland should be done as far as farming activities along the riparian zones, encroachment and demarcation of the wetland is concerned.

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