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Macro-invertebrate assemblages as indicator of ecological integrity of Kingwal Wetland

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Abstract
In Kenya, the wetlands are undergoing continuous human encroachment and anthropogenic activities that may affect their ecological integrity. This study was conducted to assess this impact by establishing macroinvetebrates species and indices along different disturbance gradients. Data was collected monthly and analyzed through frequency distributions, cross-tabulation, chi-square, and Analysis of Variance as appropriate. Macroinvertebrates species richness was found to be highest at Kesses site which was a relatively low disturbance area with 28 species, followed by site Kingwal Bridge with 24 species and site Kiptenden with 23 species while Kimondi had the lowest species richness of 19 species. In terms of % OC relative to the total macroinvertebrate, Kesses had the highest value (6.1%) followed by Kingwal (4.5%), and the third was Kiptenden (1.9%). The overall % EPT was highest in the Kesses and lowest in Kingwal. Kesses had high IBI scores and these decreased downsream. There was generally a significant ($p < 0.05$) negative relationships between M-IBI and HDI. The current results indicate that the anthropogenic activities are resulting in differences in macroinvertebrate assemblages and can thus be used for biomonitoring.

***Key Words**: Macroinvertebrates, Disturbance, Index of biotic integrity*

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I. Introduction

Wetlands can be described as areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support, aquatic vegetation and where depth of water does not exceed six metres (Ajwang et al., 2016). Wetland as an ecosystem is among the most productive in the world and are critical for supporting human livelihoods in Africa (Rebelo et al., 2010; Andere, 2016). They provide goods and services such as food, agricultural production, fisheries, water and air quality maintenance as well as recreation to human populations (Bassi et al., 2014). They are also important sources of water and nutrients that support biological productivity (Schuyt, 2005) and serve as habitats for diverse species (Cooper et al., 2006). Wetlands have been found to reduce the severity of droughts and floods by regulating stream flow and can provide vital water resources to support agricultural production (McCartney and Houghton-Carr, 2009).

Most wetlands in Kenya face growing anthropogenic pressure and are mostly affected by overexploitation, changes in water quality, eutrophication, organic loading, invasive species, and hydrographic changes in aquatic systems (Kansiime *et al*., 2007; Farber and Costanza, 2007; Davidson, 2014). Continued increase in human activities and expansion of settlements (Korir and Mulongo, 2010) may further modify the wetland ecosystem's integrity. However, concerns are being raised about the integrity of many wetlands to perform these ecological functions (Eliška *et al*., 2008; Cole *et al*., 2010).

Nandi County has many wetlands including King'wal which has unique habitats for several species of flora and fauna, some of which are endangered species. In the recent times, there have been increased expansions of human settlements due to population increase that have not spared the riparian ecotones, as well as the areas covered by the wetlands. Intensification of human activities in these wetlands will continue to threaten the species of flora and fauna in these unique habitats. The utilization of wetland plant and animals without proper management regimen poses a risk to the ecological and functional integrity of the wetland manifested through effects on the organisms. There is need for more data on the utilization and management of many wetlands in Kenya including King'wal as this has continued to hamper the formulation of policies on sustainable utilization and management of these wetlands.

The wetlands in Nandi County are under threat as a result of intensive pressure to convert them or over-use their resources under the premise that this benefits the local people. Physical survey shows that there are a number of factors that influence the resource utilization of the wetlands. This is important because any policy being drawn ought to focus on the drivers of the wetland utilization. Wetland destruction is undertaken at the household levels because of lack of understanding about the basic ecology and biodiversity. Knowledge of biodiversity in the wetland will be useful in educating the local on the need for wetland conservation.

Information on wetland biotic assemblage is needed because of its potential usefulness in understanding the relative extent of plant biodiversity and its implication for conservation and management. Therefore, to promote effective conservation and optimize the benefits from the wetland, ecological and taxonomic studies to provide adequate information about wetland components and processes are required. Results on composition and other indices of benthic macro-invertebrates are fundamental for the understanding of the ecological status of a wetland. The study can thus serve as a baseline in determining to what extent the wetland is affected by the surrounding land use and could also be used to monitor changes in the wetland.

II. Materials and Methods

2.1 Study Area

This study was done in Kingwal Wetland within Nandi County. The wetland is located between latitude: 35°08’34.1”E to 35°11’22.0”E and longitude: 0°15’11.3”N to 0°16’13.6”S (Figure 1). The total surface area of the swamp is about 1218 km^2.

Rainfall within the vicinity of Kingwal Swamp is reliable and evenly distributed with two peaks in April to May and in August and a drier spell from November to February (Cherono et al., 2018). The mean annual rainfall of 1100 mm although some areas receive up to 1500 mm while the average temperature in the area is 23°C during the wet season with a maximum of 27°C during the dry season and a minimum of 12°C in the coolest season. February is the hottest month, and June is the coolest. The swamp is within Lake Victoria basin and catchment zone.

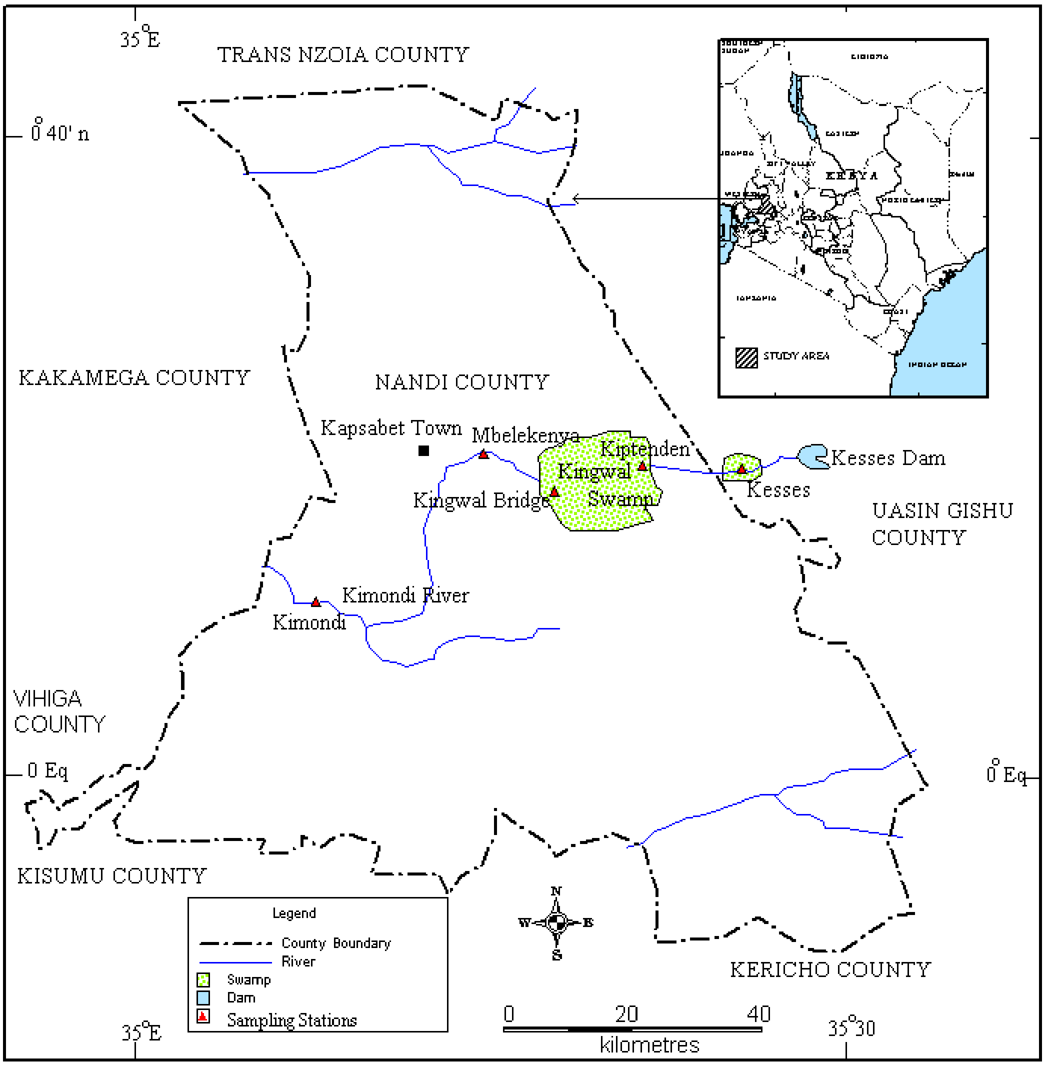

Figure 1: Map showing the location of Kingwal Wetland. Inset; Map of Kenya

2.2 Sampling Sites

During the preliminary reconnaissance survey, four sampling sites were identified. Site S1 (Kesses), was located at the source of River Kesses. The riffles at the station had substrates made of stones, pools consisted of mud and detritus material, while runs had mud substrates. The station had an average depth of 0.6 m with an average width of 2 m. The riparian zone was swampy with black clay soils dominating the area. Human activities around the station were minimal and was therefore used as a reference station in the development of an IBI because of minimal anthropogenic disturbance observed.

Site S2 (Kiptenden) was located midstream of River Kesses. The riffles at the station had substrates made of stones; pools consisted of mud and detritus material, while runs had mud substrates. The station had an average depth of 0.6 m with an average width of 2 m. The riparian zone was less swampy with black loam soils dominating the area. Human activities around the station were prominent with agricultural farms and grazing land. The station was characterized by human disturbance and nearby homesteads around.

Site S3 (Kingwal Bridge), was located at the midstream of River Kesses. The pools and runs at the station had substrates consisted of mud and detritus material, The station was much deeper than the first two sites with an average depth of 1.0 m with an average width of 2.5 m. The riparian zone was swampy with black clay soils dominating the area. Human activities around the station were prominent including brick making, agriculture, tree nurseries, horticulture and papyrus harvesting. There were many papyrus stems decomposing in the stream hence an expected low DO and high BOD. There were many households located around the site.

Site S4 (Kimondi), was located downstream of River Kesses. The pools and runs at the station had substrates consisted of mud and detritus material, The station, like station three, Kingwal Bridge, was much deeper than the first two sites with an average depth of 1.0 m with an average width of 2.5 m. The riparian zone was swampy with black clay soils dominating the area. Human activities around the station were prominent including brick making, agriculture, tree nurseries, horticulture and papyrus harvesting. There were many papyrus stems decomposing in the stream hence an expected low DO and high BOD. There were many households located around the site.

2.3 Sampling and Data Collection

Triplicate benthic samples were collected at random locations in each of the selected sites with a sampler (0.1 m^2, 300 μm mesh size). Approximately 0.3 × 0.5 m area was disturbed vigorously for 30 sec, so as to avoid escape of large macro-invertebrates. The contents of the net were all emptied into polythene bags. The macro-invertebrates collected were then preserved using 75% ethanol, and transported to the laboratory for sorting and identification. Identification to the lowest possible taxon and counting were done using a WILD stereoscope microscope with magnification power of 20× and the macroinvertebrates identification keys (Day *et al.*,, 2002; de Moor *et al.,* 2003; de Moor 2003a,b; Bouchard, 2004; Stals and de Moor 2007; Merritt *et al.,* 2008).

The composition measures were used in the determination of the relative abundance of benthic macro-invertebrate assemblages. They were used to serve as an indicator of their role in the collaborative energy and food cyclic processes in the river. The collected samples compositional metrics were obtained through laboratory identification using a dissecting microscope at × 50 magnification. They included relative abundance, taxonomic richness, taxonomic diversity (Shannon Weiner index), % EPT, and % tolerant taxa.

2.4 Development of Index of Biological Integrity

Development of biological indicators followed a three-step approach that incorporated univariate, multivariate and multimetric analyses (Li et al., 2010). The first step was exploratory; candidate metrics were evaluated with univariate t-tests. The initial candidate metrics were from three broad categories that included proportional abundance, proportional biomass, and taxa richness. Within each of these categories evaluation was performed at the species, habitat guild and feeding guild, and voltinism levels. A large number of candidate metrics was initially considered because limited information exists on how invertebrate communities of seasonal floodplain wetlands are affected by disturbances. Candidate metrics were eliminated in the first step of metric development using an acceptance level of $P < 0.1$. In the second step, all candidate metrics identified from the t-tests were input into a stepwise-discriminant function analysis to yield the final M-IBI metrics (STEPDISC procedure, SAS Institute 1999). Once the M-IBI metrics were developed, a correlation matrix was run to determine if colinearity existed between the metrics.

Sensitivity analysis was performed to identify which metrics were the most influential in determining the M-IBI score (Li *et al*. 2010). Each of the metrics was removed from the overall M-IBI based on their correlation with the H-IBI scores. The overall evaluation of wetland condition was conducted by determining the average and median M-IBI scores of the randomly selected wetlands sites. Both the average and median scores were evaluated using the qualitative condition scores selected to determine overall wetland condition at each site.

The metrics (measures) listed below were used to assess the health of the wetland. An increase in each metric produces the shown predicted response of the wetland health. Each metric receives a score of one, three, or five. The metrics are then totaled to produce an overall IBI score. The interval 1, 3, 5 scoring system used in developing macroinvertebrate IBIs (Aura et al., 2010) was adopted to normalize the ranges of metrics. The score is then interpreted into a general health rating of Excellent, Moderate or Poor.

Table 1: Metrics used to assess the health of the wetland

Metric	Metric definition (increase in..)	Predicted response on wetland health
Number Ephemeroptera genera	Total number of mayfly genera: These are sensitive to pollution	Increase
Number Plecoptera genera	Total number of stonefly genera	Decrease
Number Trichoptera genera	Total number of caddisfly genera	Increase
Number Ephemeropter-Plecoptera-Trichoptera genera	Total number of taxa from mayfly, stonefly and caddisfly orders	Increase
Total number of macro-inveterbrate genera	All different genera at a site	Increase
Percent EPT individuals	% individuals from mayfly, stonefly and caddisfly orders	Increase
Number of diversity of leeches	The number of leeches is greater in healthier wetlands.	Increase
Percent Coleoptera proportion	% beetles/bugs. Aquatic beetles are predators. They feed on algae and detritus that increase in polluted wetlands.	Decrease
Number of Odonata genera	The number of dragonfly and damselfly larvae.	Increase
Percent non-insect individual	% of individuals not belonging to the insect orders	Increase
Percent Diptera individuals	% of midges	Increase
EPT: Diptera ratio	Ratio of individuals belonging to mayfly, stonefly and caddisfly orders to that of midges	Decrease
Percent dominant 3 genera	% of individuals in 3 most dominant genera	No response
Number intolerant genera	Total number of taxa belonging to pollution intolerant genera	Increase
Number of Pulmonata genera	Number of snails. The number of snails is greater in higher quality wetlands than in disturbed wetlands.	Increase
Mullusca+ Crustacean genera	% of mollusks and crustaceans	Increase
EOT richness	Ephemeroptera, Odanata and Trichoptera richness	Increase
Percent filterer individuals	Filter fine organic material	Decrease
Percent scraper individuals	Feed on algae at the bottom	Increase
Percent predator individuals	Carnivores- scavangers, engulf or pierce prey	Decrease
Percent gatherer individuals	Collect fine deposited organic material	Increase
Shannon diversity index	Value of Shannon diversity index	Increase
Simpson richness index	Value of the Simpson richness index	Increase
IBI Score	Wetland Health Assessment Score	Rating
97-120	5	Excellent
49-96	3	Moderate
24-48	1	Poor

2.5 Data Analysis

All statistical analyses were performed with Minitab version 15. Normality and homoscedasticity of data distribution was checked by means of the skewness and kurtosis (Zar, 2001). In case where data was found not to follow normal distribution (heteroscedastic), log (x+1) transformation was used to normalize all the biological data (Michael and Douglas, 2004).

Wetlands species composition data were analyzed through frequency distribution, percentage frequencies and chi-square (χ^2). Differences in the physico-chemical parameters (temperature, pH, conductivity, DO and the nutrients) among sites were analyzed using a one-way ANOVA. Differences in both spatial and temporal variability were analyzed by Two-way ANOVA. Spatial differences in the macroinveterbrate species abundance and diversity were analyzed through One-Way ANOVA and diversity indices respectively. Duncans Multiples Range Test (DMRT) was used for Post-hoc separation of significant differences (Michael and Douglas, 2004). The assumption of normality prior to ANOVA was verified using the Shapiro–Wilk test. Significant differences were analysed by *post hoc* Tukey's HSD test. Differences in macroinvertebrate community (abundance, richness, H', %OC, %EPT, and % FFG) were analyzed using One-Way ANOVA. All results were declared significant at $P < 0.05$.

III. Results

3.1 Physico-chemical properties of the water

All the physico-chemical water quality parameters displayed significant spatial variations (Table 2). The water pH was highest at Kingwal Bridge than all the other stations and ranged between 5.1 and 7.6. The concentration of DO decreased from upstream towards the downstream part of the river, in contrast to the trends for the BOD. The conductivity was highest at Kingwal Bridge while lowest in Kimondi. The Total nitrogen (TN) and total phosphorus (TP) were significantly highest in Kesses followed by Kiptenden sampling sites.

During the entire study period, the pH demonstrated significant ($p < 0.05$) spatio-temporal variations increasing to a pick in April to May and was low during the June-July-August period. The concentration of pH in water Kesses was acidic and displayed significant spatio-temporal variation ($p < 0.05$) increasing to the highest values between March-April-May period and then reduced. The concentration of pH in Kiptenden and Kimondi were intermediate between Kesses and Kingwal and displayed significant spatio-temporal variations ($F = 23.123$, $P < 0.05$).

Significant ($F = 8.9232$, $P = 0.0025$) temporal variations in surface water conductivity were recorded in Kesses, Kiptenden and Kingwal Bridge but not in Kimondi and was generally lowest from July to December in all sites. However, from January to April, higher conductivities were recorded in all the study sites, except in Kimondi.

Table 2: Selected physico-chemical attributes (Mean ± SE) of the water in the five sampling locations.

Parameter	Sites				Statistics	
	Kesses	Kiptenden	Kingwal Bridge	Kimondi	F-values	P-value
pH	6.07 ± 0.25[a]	6.90 ± 0.19[b]	7.72 ± 0.10[c]	6.71 ± 0.21[b]	44.221	0.000
Dissolved oxygen (mg L^{-1})	8.29 ± 1.3[c]	6.88 ± 1.01[b]	1.04 ± 0.63[a]	1.42 ± 0.22[a]	19.332	0.001
Biological Oxygen Demand (BOD)	2.44 ± 0.22[a]	2.41 ± 0.33[a]	7.44 ± 0.22[c]	5.11 ± 0.32[b]	9.443	0.008
Conductivity (μS cm^{-1})	344.1 ± 13[d]	140.5 ± 15.9[b]	182.3 ± 8.9[c]	98.2 ± 3.8[a]	35.23	0.002
Total nitrogen TN (mg L^{-1})	2.72 ± 0.41[c]	1.71 ± 0.3[b]	1.02 ± 0.2[a]	1.11 ± 0.2[a]	19.551	0.005
Total phosphorus (mg L^{-1})	2.08 ± 0.46[c]	1.01 ± 0.42[b]	0.76 ± 0.19[a]	1.23 ± 0.08[b]	16.992	0.005

[1]Means with the same letters as superscripts are not significantly different ($p > 0.05$).
[2]SE: Standard Error of the mean

There were significant ($F = 7.9732$, $P = 0.0002$) temporal differences in DO among sites except Kesses and Kingwal Bridge. The widest fluctuation of DO was recorded in Kimondi site, where higher DO occurred between May and August and lowest DO being in September and October.

The concentration of Total Nitrogen (TN) in water was significantly different ($F = 34.5343$, $P = 0.0000$) between the sites (Figure 2a). In Kiptenden, TN was higher between January and August. Kingwal Bridge on the other hand, maintained a high concentration between January and August. In Kesses, TN concentration was only high in April but lower in other months of the year.

The concentration of Total Phosphorus (TP) in water and soils differed significantly ($F = 11.2321$, $P = 0.0001$) during the sampling periods (Figure 2b). Overall trends of TP in water were a general increase from January to December. However, Kingwal Bridge showed deviation from this trend from August to December. In Kimondi, decline in TP between January and April was preceeded by a significant increase in this nutrient between April and December. In Kingwal Bridge, the concentration of TP was lowest between January and April but increased in the month of August. At Kiptenden site the concentration of soil TP was significantly higher in December as compared to the other months.

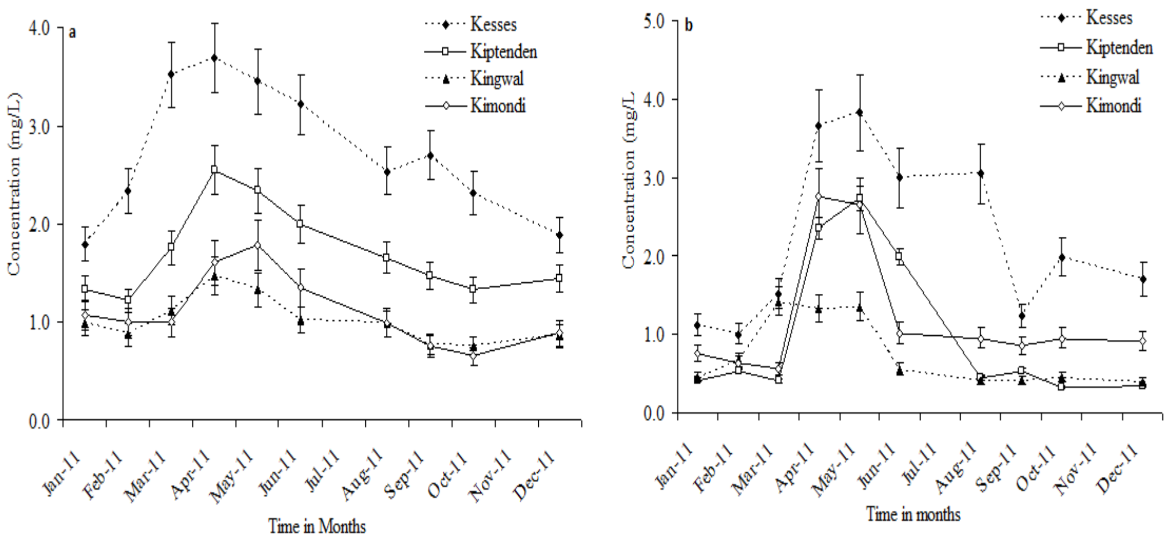

Figure 2: Spatio-temporal variation in nutrients concentrations at Kesses, Kiptenden, Kingwal Bridge and Kimondi Swamps between January and December (a – TN, b – TP).

3.2 Macro-invertebrate assemblage

The macroinvertebrate distribution in the sampling locations of Kingwal Swamp is provided in Table 3. Macroinvertebrates species richness was found to be highest at site 1, Kesses, with 28 species, while site 4, Kimondi, had the lowest species richness (19 species). *Gyrinus* sp., *Chronomus* sp., *Baetis* sp., *Caenis* sp., *Geriis* sp., *Agrion* sp. *Physa* sp. and *Hydropsyche* sp. appeared in all the sampling sites.

Table 3: Distribution in terms of presence (+)/absence (-) of various genera of macro-inverterbrates at the Kesses, Kiptenden, Kingwal Bridge and Kimondi between January and December 2011.

Order	**Family**	**Genus**	Kesses	Kiptenden	Kingwal Bridge	Kimondi
Coleoptera	Dytiscidae	*Heptogenia*	-	-	+	-
		Ilybius	+	+	-	-
		Platambus	-	+	-	-
	Gyrinidae	*Gyrinus*	+	+	+	+
	Haliplidae	*Haliplus*	-	-	+	-
	Noteridae	*Hydrocanthus*	+	+	-	+
Diptera	Anthomyiidae	*Limnophora*	+	-	-	-
	Chironomidae	*Chironomus*	+	+	+	+
	Tipulidae	*Tipula*	+	-	-	-
	Simulidae	*Simulium*	+	+	-	+
Ephemeroptera	Baetidae	*Baetis*	+	+	+	+
	Caenidae	*Caenis*	+	+	+	+
	Coenidaie	*Coenus*	-	-	+	-
	Ecdyonuridae	*Heptogenia*	+	+	+	-
	Ephemerallidae	*Ephemeralla*	-	+	-	-
	Leptophtebiidae	*Habrophlebia*	+	-	-	-
Hemiptera	Corixidae	*Collicorixa*	+	+	+	-
		Corixa	+	+	+	-
	Gerridae	*Gerris*	+	+	+	+
	Hydrometridae	*Hydrometra*	-	-	+	-
	Mesoralidae	*Mesorelia*	-	-	-	+
	Notonectidae	*Notonecta*	-	-	-	+
	Physidae	*Phymata*	-	-	+	-
	Pleidae	*Gomphus*	-	-	+	-
Lamellibrandiata	Sphaeriidae	*Sphaerium*	+	-	+	-
Odonata	Agridae	*Agrion*	+	+	+	+
	Cordulegasteridae	*Cordulegaster*	+	+	-	-
	Gomphidae	*Gomphus*	+	+	-	+
	Plactyenemididae	*Pyrrhsoma*	+	+	+	+
		Enallagma	+	-	-	+
Prosobranchiata	Valvatidae	*Valvata*	+	-	-	+
Pulmonata	Limnaeidae	*Limnaea*	+	+	+	+
	Physidae	*Physa*	+	+	+	+
	Planorbidae	*Planorbis*	+	+	+	-
Trichoptera	Hydropsychidae	*Hydropsyche*	+	+	+	+
		Tinodes	+	+	-	-
Plecoptera		*Nemouridae*	+	+	-	-
		Neoperla	-	-	+	-
Oligochaeta	Lumbricidae	*Lumbricus*	+	-	+	+
Crustacea	Decapoda	*Eriocheir*	-	-	+	+

Abundance of different macroinverbrates orders sampled during the study is provided in figure 3 below. The wetland was generally dominated by Pulmonata and odonata orders accounting for 24.5% and 21.2% respectively. Orders Coleoptera, Ephemeroptra, and Hemiptera had a relative proportion of 10% and above whereas Crustacea, Plecoptera and Trichoptera occurred in low proportions of below 2% each. Higher abundance of Coleoptera, Hemiptera, Odonata, Oligochaeta, Prosobranchiata and Pulmonata occurred in the Kesses (H = 17.907, df = 3, p = 0.0003) while in Kiptenden only trichoptera was more abundant orders (H = 4.911, df = 3, p = 0.0318). Diptera was more abundant macroinvertebrate order in Kingwal (H = 4.1232, df = 3,

$p = 0.0415$). In Kimondi, Ephemeroptera was the only dominant order of macroinevtebrate ($H = 13.5422$, $df = 3$, $p = 0.0003$).
Kruskall-Wallis test revealed significant differences in abundance of the species among the sampling sites ($H = 7.987$, $df = 3$ $p = 0.0193$). Kesses had the highest abundance of macro-invertebrates and the abundance decreased thereafter from Kesses to Kimondi.

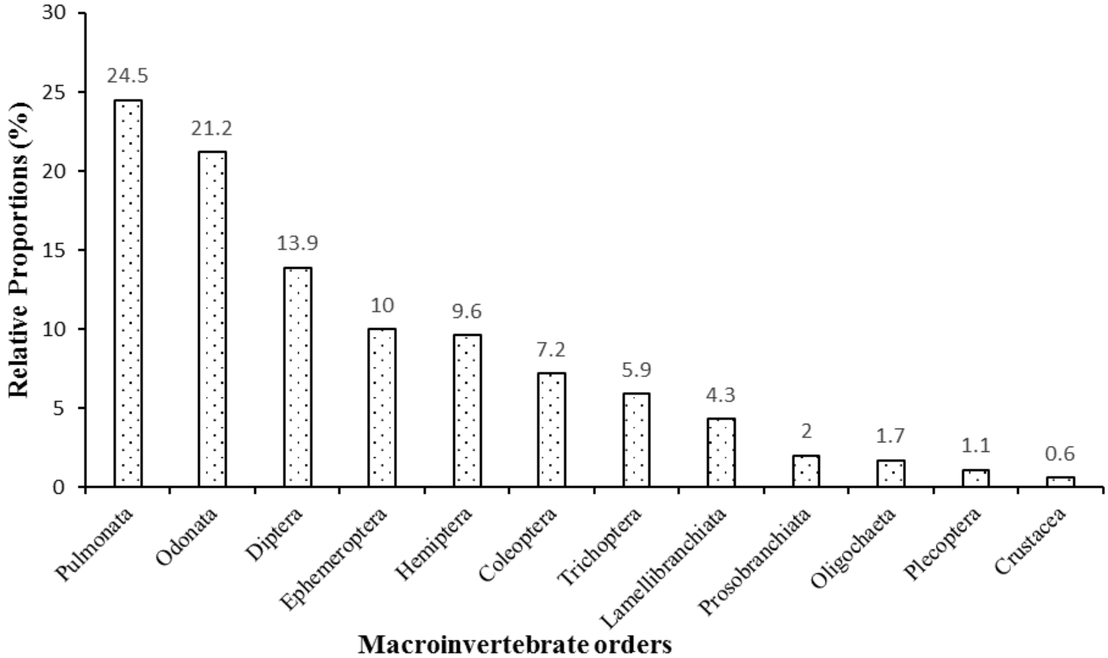

Figure 3: Percentage contribution of each order of the macro-invertebrate to total macroinvertebrate abundance in Kingwal wetland between January and December

The percentage contribution of each order of the macro-invertebrate to total macroinvertebrate abundance in Kingwal Wetland between January and December is provided in Figure 4. The abundant coleopteran and hemiptera occurred in the Kesses while large number of Ephemeroptera, Plecoptera and Trichoptera occurred in the Kimondi.

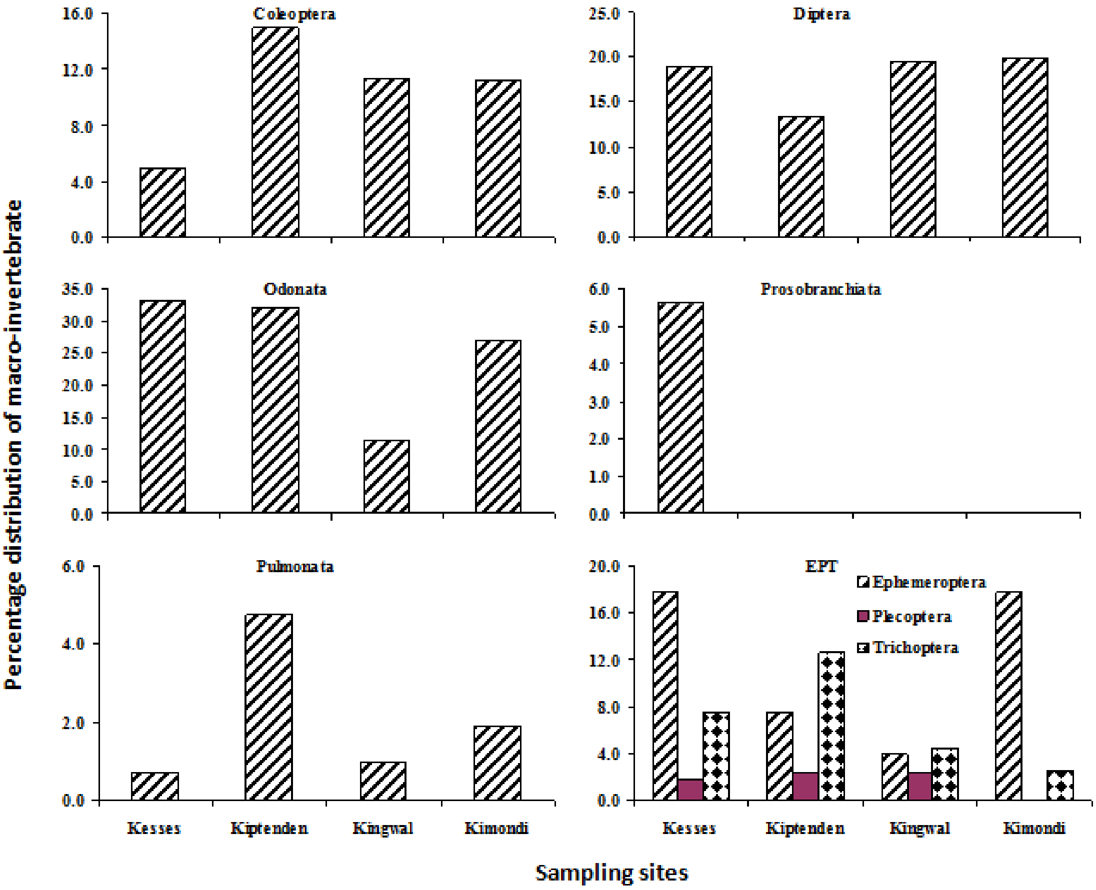

Figure 4: Percentage contribution of each family of the macro-invertebrate to total macroinvertebrate abundance at the Kesses, Kiptenden, Kingwal Bridge and Kimondi between January and December.

3.3 Macro invertebrate Index of Biotic Integrity (M-IBI)

The human disturbance score (HDI score) are provided in Figure 5. The scores for sites 4 to 6 were found to be 2.5 times higher than the reference sites while sites 7 to 12 had HDI about 5 times higher than the reference sites.

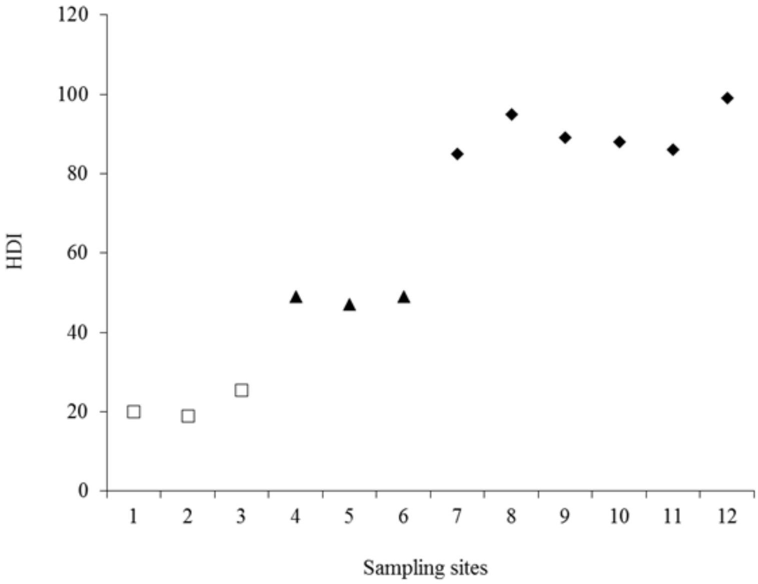

Figure 5: Distribution of the Human Disturbance Index Ranked from Lowest to highest Score. The scores for sites 4 to 6 were found to be 2.5 times higher than the reference sites while sites 7 to 12 had HDI about 5 times higher than the reference sites.

The raw scores of the metric of the 23 macro-invertebrates selected metrices was first conducted. However, not all the metrices showed show significant relationships to the human disturbance score in the three sites. Based on the significant scores of the selected metrices, 12 metrices were selected and used to develop the IBI. The IBI Scores is provided in Figure 5. The reference sites had high IBI scores and the scores decreased downstream.

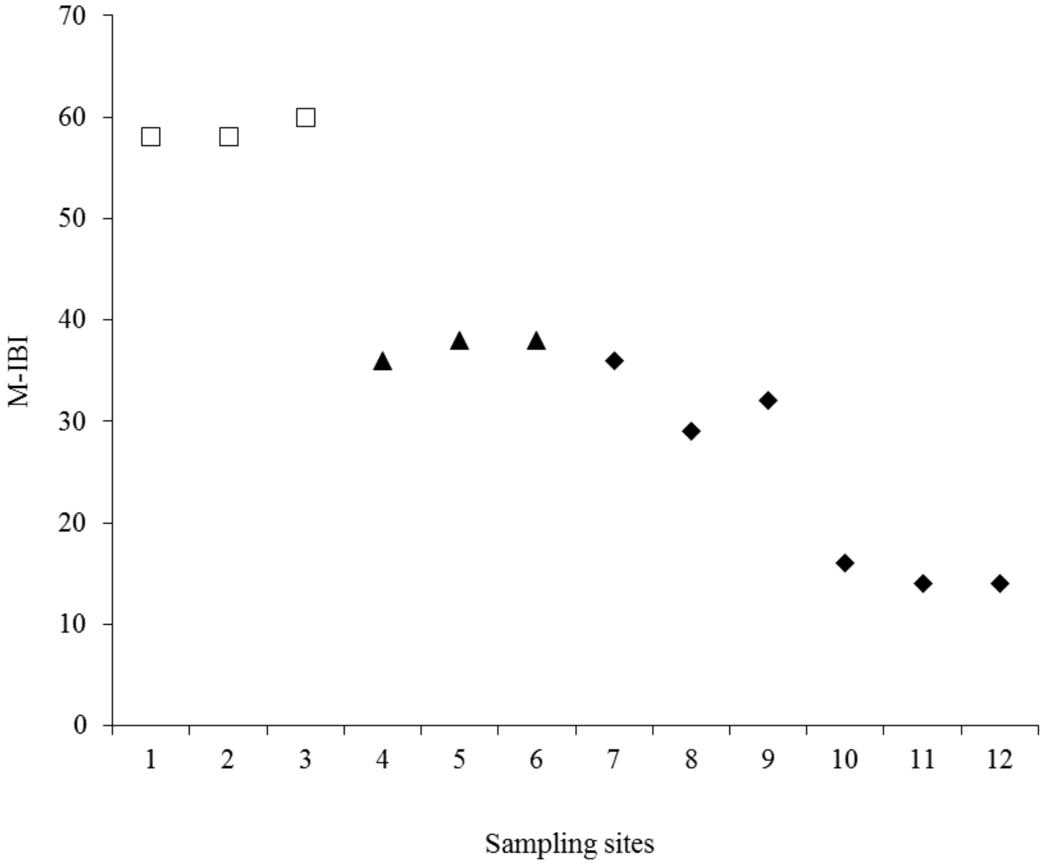

Figure 6: M-IBI developed to assess the status of various sampling sites of Kingwal Wetland

The linear regression between the H-IBI and the IBI developed in the study is shown in Figure 7. There was generally a significant ($p < 0.05$) negative relationships between H-IBI and IBI developed for the different sampling sites along the swamp.

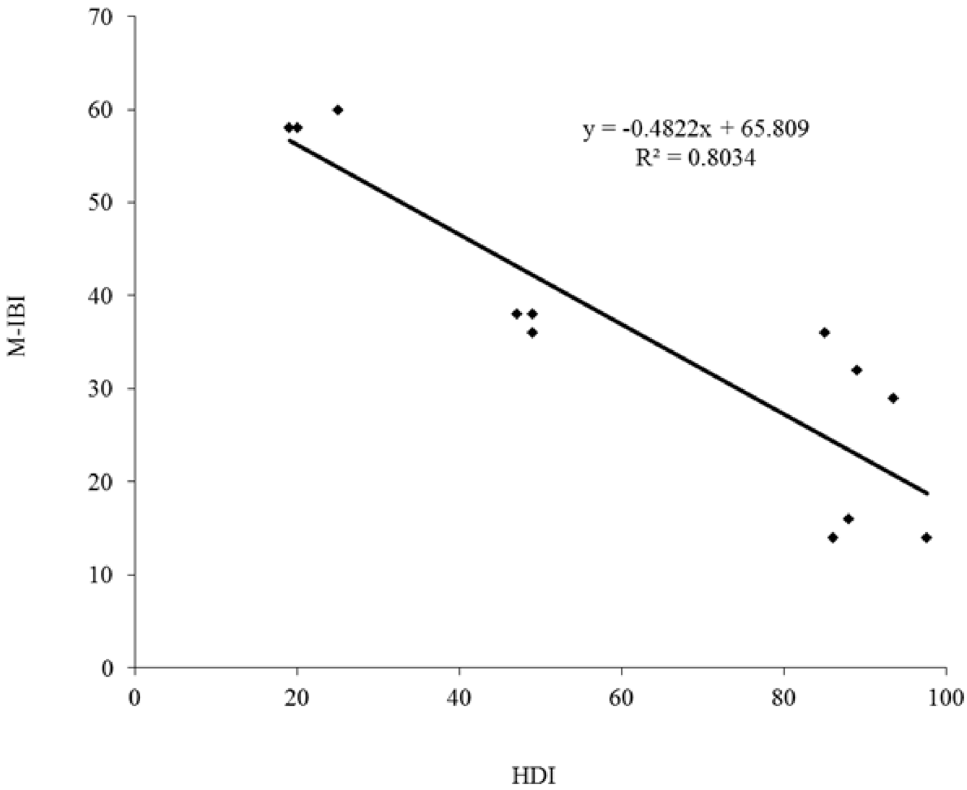

Figure 7: Linear regression between the M-IBI and HDI for different sampling sites of Kingwal Wetland.

IV. Discussion

Wetland studies have shown that macroinvertebrate data provide useful measures of ecological health in wetland biomonitoring (Orwa et al., 2013). Similarly, this study showed that it was possible to discern differences between reference and impaired stations within Kingwal wetland using macroinvertebrate community attributes. The metrics selected for the final M-IBI all have an ecological rationale.

A major assumption of the IBI approach is that metric values change linearly with increasing (or decreasing) disturbance (Aura et al., 2010; Li et al., 2010). Taxa richness for example is a commonly used metric because it is generally assumed that undisturbed wetlands support more species (US. EPA 2002). Using an empirical approach, it was found that total taxa richness was not an important discriminatory variable for distinguishing reference and impaired wetlands. It was predicted that the greatest diversity would occur at low levels of disturbance. The results of this however showed that taxa richness was greatest at intermediate levels of M-IBI scores. It is this nonlinear response to disturbance that precluded total taxa richness from becoming an important metric in the final M-IBI. Furthermore, this type of relationship suggests that those developing wetland IBI's should be cautious when using total taxa richness as a metric in the final IBI.

According to Gernes and Helgen (2002), HDS ranges from 0 (no evidence of disturbance) to 100 for the most disturbed sites. The ranges 3-33, >33- 67 and > 67-100 HDS can be considered as the least disturbed, mid-disturbed (impaired wetlands) and the most disturbed sites, respectively. Accordingly, site 4-6 sites were found to have low HDS scores with 21 and 14 points, respectively. As both sites scored in the range 3-33 points, they are categorized as the least disturbed while site 7 to 12 sites scored relatively high HDS, and is categorized as moderately to highly disturbed wetland. Evaluation of the randomly selected wetlands revealed that most wetlands rated in fair condition. This conclusion was not surprising because many of the sites were generally impacted by human disturbance and had signs of moderate grazing or were in proximity to agricultural activities, although few were isolated from all types of disturbances as was the case with sites 1a, 1b,1c selected at site 1, Kesses sampling site.

V. Conclusion

The aquatic flora and fauna in wetlands can be affected by the degree of human disturbances in the catchment. H-IBI scores and the data for all of the individual metrics did showsignificant impairment as measured by human disturbance scores. This shows that the different human activities such as agriculture, grazing, brick making, etc. being undertaken in the catchments have resulted in severe impacts to the status of the wetlands' current biological integrity.

VI. Recommendation

A number of human activities observed during the study period may result in irreversible damage to the wetlands. If the degree of human activities continues to increase at its current lack of conservation and management practices, this may result in greater reduction in flora and fauna species and will have negative impacts on the overall biological integrity and sustainability of the wetland. Thus, implementing a catchment-based wetland management and conservation plan is necessary to address the upcoming problems. Awareness creation on the sustainable management of wetlands within the farming communities, concerned government staffs and local decision makers is also important. Building the capacity of local communities through interactive training towards community participatory conservation activities is crucial.

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