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# Analysis Of Physico-Chemical Parameters And Selected Heavy Metals In Aquatic Ecosystems.

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***Abstract***
*The quality of aquatic ecosystems is of great concern. Elevation of pollutants in water could cause health disorders in human and destabilize the aquatic ecosystem. The case study investigated quality of water from five sites of Lake Turkana selected based on proximity to potential anthropogenic pollution sources. Temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), salinity, total dissolved solids (TDS) and Oxidation-Reduction Potential (ORP) were measured at the site using YSI Pro 1030 Multiparameter electrode while nitrates and phosphates were determined at Kenyatta University's food science laboratory using Vis 130 Spectrophotometer. Selected heavy metals (lead, cadmium and chromium) were determined using flame atomic absorption spectroscopy. Sampling was performed in triplicates during the dry season. The results were: temperature (28.24±0.96 to 28.86±0.38°C), pH (9.04±0.21 to 9.46±0.06), electrical conductivity (281.57±0.41 to 289.46±3.95 $\Omega cm^{-1}$), dissolved oxygen (6.3±0.79 to 7.04±0.05 mg/L), salinity (1.67±0.00 to 1.70±0.01 ppt), TDS (2093.4±0.39 to 2135.8±4.86 mg/L), ORP (-54.22±0.12 to 588.14±0.51 mV), nitrates (5.52±0.31 to 10.04±1.82 mg/L) and phosphates (0.47±0.06 to 0.72±0.15 mg/L). Water lead (0.11±0.01 to 0.12±0.00 mg/L), cadmium (0.00±0.00 to 0.03±0.00 mg/L) and chromium (0.01±0.00 to 0.03±0.01 mg/L). The results showed that pH and TDS were beyond WHO standard of 6.5-8.5 and 600.0 mg/L respectively while phosphates exceeded USEPA limit of 0.024 mg/L in all sites. The electrical conductivity and nitrates complied with WHO standards of 400.0 $\Omega cm^{-1}$ and 50.0 mg/L respectively while the other parameters were not guided by WHO. The lead levels in water exceeded WHO standard of 0.01 mg/L in all sites. The cadmium levels in Impressa and Long'ech beaches in the upstream section exceeded WHO standard of 0.003 mg/L. However, chromium complied with WHO standard of 0.05 mg/L in all sites. These calls for measures keep all the parameters under surveillance to ensure water quality is maintained.*

***Key Words:*** *Kenya, physico-chemical parameters, heavy metals, Lake Turkana*

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## I. Introduction

Safe water has been scarce in recent years due to climate change [[1], [2], [3]]. The situation has been exacerbated by anthropogenic activities such as industries and increased farming activities [[4], [5], [6], [7]]. Environmental pollution remains a top cause of diseases [[3], [8]] as scientists continue to offer solutions to pollution monitoring and prevention.

The physico-chemical analysis in lake water remains a suitable technique for water quality determination. For instance, elevated electrical conductivity in water indicates high level of ionic contaminants. However, biomonitoring technique has evolved which involves pollutant analyses in biological matrices and analysis of the biomonitoring data to extrapolate persistent pollutant's characteristics such as pollutant concentration estimates in the environment, health effects, pollutant's source and exposure pathways [[9]]. As an example, the fish is a biomonitoring organism of interest in aquatic pollution [[9], [10], [11]]. Although, the biomonitoring technique is faster and cheaper, it is limited by ethical barriers in humans, uncertainty due to extrapolation and simultaneous exposure to different pollutants ([3], [9]]. To safeguard public health, WHO derives water quality standards by analyzing information from several suitable techniques [[3]].

In Kenya, eutrophication has hindered fisheries in lakes due to continuous nutrient influx [[12], [13], [14], [15]]. In Lake Turkana for instance, the use of inorganic fertilizers from the expanded irrigation agriculture in the region could potentially increase inorganic pollutants in the lake [[16], [17]]. This could be the main source of nitrates and phosphates that end up in aquatic ecosystems through runoff [[16]]. Other sources of nutrients in Lake Turkana are untreated sewage from the lake settlements of Kalokol and Longe'ch [[3], [7]] and rapid oxidation of organic matter due to elevated lake water temperature [[3], [18]]. Similarly, Lake Turkana receives residues of motor fuels and urban wastes that are sources of organic and inorganic pollutants [[19]]. Furthermore, elevated physico-chemical parameters in Lake Turkana's water have also been reported [[7], [16],

[20]]. This study investigated the quality and safety of water from Lake Turkana by determining the level of temperature, pH, electrical conductivity(EC), dissolved oxygen (DO), salinity, total dissolved solids (TDS), oxidation-reduction potential (ORP), nitrates, phosphates and selected heavy metals, and comparing them to WHO and USEPA standards appropriately.

## II. Materials and Methods

**Study area**

Lake Turkana, the area under study is located in Turkana County, Kenya. The lake's GPS coordinates are: 3°35'N 36°7'E. Among the Rivers (Omo, Turkwel and Kerio) emptying into Lake Turkana, River Omo, far in the north from Ethiopia is the main feeder with over 80% of the total inflow [[17], [21]]. In addition, a seasonal stream next to Kalokol settlement known as Napasinyang' also drains into the lake (Figure 1). River Turkwel flows near the county's capital, Lodwar town. The lake is located in the arid and semi-arid lands (ASALs) of Kenya with mean annual temperature of 24-30°C [[16]]. The area's bedrock is of volcanic origin. Irrigation farming is intensive with approximately 913 hectares along Kerio River and 1,753 hectares along Turkwel River. The sampling positions in Lake Turkana are shown on the GPS map (Figure 1). The starting point was a gulf and the sampling sites were selected thereafter based on proximity to anthropogenic activities.

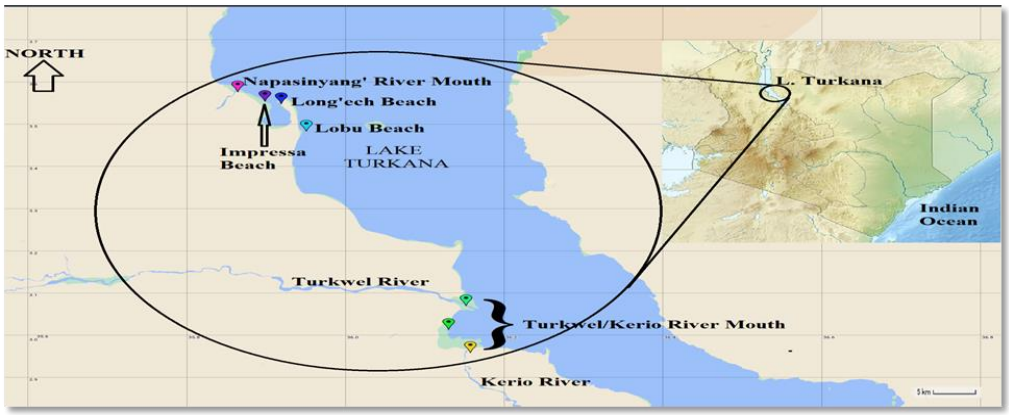


**Figure1:** GPS map of sampling sites in Lake Turkana

The selected sampling sites were Napasinyang' River Mouth, next to Kalokol settlement (Figure 2), Impressa Beach, next to Kalokol settlement and with boat painting and transportation activities (Figure 3), Long'ech Beach, next to Long'ech settlement (Figure 4), Lobu Beach, relatively far from human settlements (Figure 5) and Turkwel/Kerio River Mouth with rivers flowing near urban areas and irrigation farms (Figure 6).

**Figure 2:** Napasinyang' river mouth of Lake Turkana

**Figure 3:** Impressa beach of Lake Turkana

**Figure 4:** Long'ech beach of Lake Turkana

**Figure 5:** Lobu beach of Lake Turkana

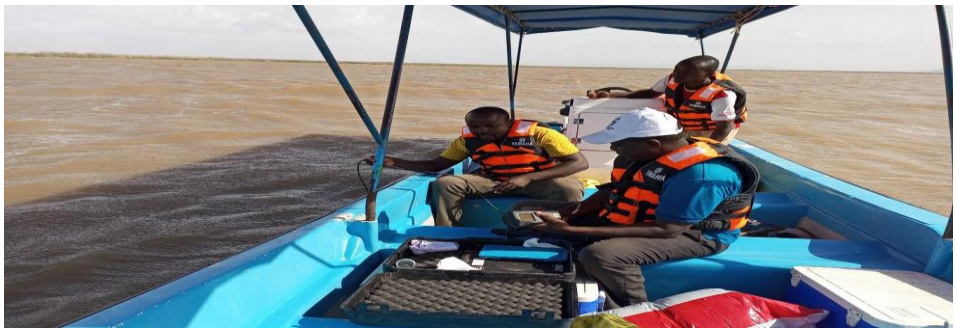

**Figure 6:** Turkwel/Kerio river mouth of Lake Turkana

**Water sampling and analysis**

The study was conducted during dry season. Physico-chemical parameters of the area; water temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), salinity, total suspended solids (TDS) and oxidation-reduction potential (ORP) were measured at a depth of 1.0 M using a pre-calibrated portable instrument (YSI Pro 1030 Multiparameter). Water samples for nutrient analysis ice preserved while for heavy metal analysis acid preserved. Nutrients and heavy metals were determined in the laboratory using

spectrophotometric methods (Vis 130 spectrophotometer) and flame atomic absorption spectroscopy (iCE3300 AA System) respectively. Sampling was done in triplicates and followed random method.

**Data analysis**

Data was recorded and expressed as Mean ± Standard Error of Mean. Levels of physico-chemical parameters and heavy metals were compared between different sampling positions using One-way Analysis of Variance (one-way ANOVA).

## III. Results and Discussion

**Physiochemical Parameters**

The physico-chemical water quality parameters of Lake Turkana tested in this study are summarized in table 1.

**Table 1:** Physico-chemical quality parameters of Lake Turkana's water

**Values were expressed as Mean ± SEM, n=3. Values with the same lowercase superscript row-wise are not significantly different (p > 0.05)**

| Sampling Sites | Napasi-nyang' River Mouth | Impressa Beach | Long'ech Beach | Lobu Beach | Turkwel/ Kerio River Mouth | WHO | USEPA |
|---|---|---|---|---|---|---|---|
| Temp (°C) | 28.24± 0.96$^{a}$ | 28.42± 0.38$^{a}$ | 28.8± 1.00$^{a}$ | 28.67± 0.02$^{a}$ | 28.86± 0.38$^{a}$ | - | - |
| pH | 9.34± 0.23$^{a}$ | 9.04± 0.21$^{a}$ | 9.28± 0.32$^{a}$ | 9.46± 0.06$^{a}$ | 9.05± 0.14$^{a}$ | 6.5-8.5 | - |
| Conductivity ($\Omega cm^{-1}$) | 286.36± 0.92$^{a}$ | 284.42± 1.00$^{a}$ | 289.46± 3.95$^{a}$ | 289.46± 1.04$^{a}$ | 281.57± 0.41$^{a}$ | 400.0 | - |
| DO (mg/L) | 7.04± 0.05$^{a}$ | 6.44± 0.65$^{a}$ | 7.02± 1.43$^{a}$ | 6.62± 0.38$^{a}$ | 6.3± 0.79$^{a}$ | - | - |
| Salinity (ppt) | 1.68± 0.00$^{ab}$ | 1.70± 0.00$^{a}$ | 1.68± 0.00$^{ab}$ | 1.67± 0.00$^{b}$ | 1.70± 0.01$^{ab}$ | - | - |
| TDS (mg/L) | 2116.22± 9.72$^{a}$ | 2126.04± 0.54$^{a}$ | 2119.14± 13.14$^{a}$ | 2093.4± 0.39$^{a}$ | 2135.8± 4.86$^{a}$ | ≤ 600.0 | - |
| ORP (mV) | -50.44± 0.16$^{b}$ | -0.36± 115.76$^{b}$ | -54.22± 0.12$^{b}$ | -49.1± 0$^{b}$ | 588.14± 0.51$^{a}$ | - | - |
| Nitrates (mg/L) | 7.65± 0.83$^{a}$ | 10.04± 1.82$^{a}$ | 5.52± 0.31$^{a}$ | 10.01± 1.36$^{a}$ | 6.92± 1.56$^{a}$ | 50.0 | - |
| Phosphates (mg/L) | 0.47± 0.06$^{a}$ | 0.67± 0.05$^{a}$ | 0.72± 0.15$^{a}$ | 0.71± 0.08$^{a}$ | 0.63± 0.07$^{a}$ | - | 0.024 |

From table 1, it was observed that the water temperature ranged: 28.24±0.96 to 28.86±0.38 °C. Data analysis showed that the temperature results were not significantly different in all sites and sections and this could be due to uniformity in water mixing by winds [[16], [22]]. The observed lake temperature could also be due to Lake Turkana's location within Arid and Semi-Arid Lands (ASALs) with mean annual temperature of 24-30°C [[16]]. Increased lake temperature could also be attributed to climate change [[1], [23]]. The higher lake temperature lowers water quality by accelerating release of heavy metal toxins [[24]].

Table 1 also showed that water pH ranged from 9.04±0.21 to 9.46±0.06 and this affirmed that water from Lake Turkana is alkaline [[16]]. The pH results exceeded WHO limits of 6.5-8.5 in all sites and sections and such elevated pH is corrosive and could destabilize processes in the lake ecosystem [[13], [25]].

It was also observed that electrical conductivity was in the range: 281.57±0.41 to 289.46±3.95 $\Omega cm^{-1}$ and was within the range of previous studies and WHO standard of 2500.0 µS/cm (400.0. $\Omega cm^{-1}$) in most sections. However, the high electrical conductivity in the upstream and midstream sections could be due to higher level of ionic contaminants from transportation and other anthropogenic activities.

The salinity level was in the range: 1.67±0.00 to 1.70±0.01 ppt. The highest salinity of 1.70±0.01 ppt was recorded in the Turkwel/ Kerio River Mouth in the downstream section while the lowest salinity of 1.67±0.00 ppt at Lobu Beach in the midstream. Elevated calcium and magnesium ions could cause the high water salinity [[3]].

Table 1 also shows that dissolved oxygen levels ranged from 6.3±0.79 to 7.04±0.05 mg/L. However, higher dissolved oxygen levels could mean higher water quality for aquatic biodiversity. Lower oxygen levels indicate that water is eutrophic due higher decomposition rate of organic matter by aerobic bacteria [[13]]. Higher temperature and weather changes among other factors lower dissolved oxygen levels in water [[16], [18]].

The TDS was recorded in the range: 2093.4±0.39 to 2135.8±4.86 mg/L. Turkwel/Kerio river mouth in the downstream section had the highest TDS of 2135.8±4.86 mg/L, indicating that water from this point and section had most dissolved salts probably from fertilizer runoff, urban and domestic wastes [[26]]. Suspended

solids in the section were also visible in the inflowing Turkwel and Kerio river water. The Lobu Beach in the midstream section recorded the lowest TDS of 2093.4±0.39 mg/L.

However, the Oxidation-Reduction Potential (ORP) levels were in the range: -54.22±0.12 to 588.14±0.51 mV. The highest ORP value of 588.14±0.51 mV was recorded at Turkwel/Kerio River Mouths. The high decomposition rate could be attributed to the rivers being rich in algae promoted by inorganic fertilizer residues from agricultural activities along the rivers [[16]].

The findings also showed that the levels of nitrates ranged from 5.52±0.31 to 10.04±1.82 mg/L. Nitrate levels were higher in Impressa and Lobu beaches. The high nitrate levels could be due to organic wastes from the Kalokol and Long'ech settlements [[7]]. The nitrate levels in all sites and sections complied with WHO standard of 50.0 mg/L.

Adverse effects by nitrates include methaemoglobinaemia, hypertension and gastric cancer [[3]].

The phosphate levels in the Lake ranged from 0.47±0.06 to 0.72±0.15 mg/L. Napasinyang' River Mouth had the lowest phosphate levels of 0.47±0.06 mg/L could be due to more phosphorus being consumed in algal growth [[27]]. The site was also located far from human settlements and agricultural activities which are likely phosphate sources [[6]]. The phosphate levels elevation beyond USEPA standard of 0.024 mg/L in the sites could be due to river influxes and surface run-off containing chemical fertilizer and phosphate-based detergent residues [[16]]. Phosphates have positive effects such as increased plant productivity and enhanced cleaning using phosphate-based detergents [[28]].

**Heavy Metal Analysis**

Heavy metals being of a global public health concern [[8]], three selected heavy metals (lead, cadmium and chromium) were analyzed in water from Lake Turkana. Water quality is greatly lowered by higher lead, cadmium and chromium levels since these are carcinogens [[8]] and have the ability to bio-accumulate in aquatic food webs [[29]].

The heavy metals have a natural origin but their increase in aquatic ecosystem is mainly influenced by anthropogenic activities [[5]].The analyzed data on the selected heavy metals in water is presented in table 2.

**Table 2:** Heavy metals in Lake Turkana's water

| Sampling Sites | Napasinyang' River Mouth | Impressa Beach | Long'ech Beach | Lobu Beach | Turkwel/ Kerio River Mouth | WHO |
|---|---|---|---|---|---|---|
| **Pb (mg/L)** | $0.11\pm0.01^{a}$ | $0.11\pm0.01^{a}$ | $0.11\pm0.01^{a}$ | $0.12\pm0.00^{a}$ | $0.12\pm0.00^{a}$ | 0.01 |
| **Cd (mg/L)** | $0.00\pm0.00^{c}$ | $0.02\pm0.00^{b}$ | $0.03\pm0.00^{a}$ | $0.00\pm0.00^{c}$ | $0.00\pm0.00^{c}$ | 0.003 |
| **Cr (mg/L)** | $0.02\pm0.01^{a}$ | $0.01\pm0.00^{a}$ | $0.03\pm0.01^{a}$ | $0.02\pm0.01^{a}$ | $0.01\pm0.01^{a}$ | 0.05 |

**Values were expressed as Mean ± SEM, n=3. Values with similar lowercase superscript row-wise are non-significantly different (p > 0.05)**

From table 2, the study recorded water lead levels in the range: 0.11±0.01 to 0.12±0.00 mg/L. The lead levels in water exceeded WHO standard of 0.01 mg/L in all sites. The Lobu Beach in the midstream and Turkwel/Kerio River Mouth in the downstream had the highest lead levels of 0.12±0.00 mg/L. This could be due to transportation activities [[30]] at Lobu Beach and urban waste and chemical fertilizer residues in Turkwel and Kerio river influxes [[16]].

Cadmium levels were also observed to be: 0.00±0.00 to 0.03±0.00 mg/L. The Long'ech Beach in upstream section had the highest cadmium level of 0.03±0.00 mg/L and this could be due to wastes from the Long'ech settlements [[7]]. The cadmium levels in Impressa and Long'ech beaches in the upstream section exceeded WHO standard of 0.003 mg/L, indicating a health threat.

It was noticed that the chromium levels were in the range: 0.01±0.00 to 0.03±0.01mg/L. The Long'ech Beach in upstream section recorded the highest chromium level of 0.03±0.01mg/L. could be due to transportation activities [[19]]. However, the chromium levels in all studied sites complied with WHO standard of 0.05 mg/L.

## IV. Conclusion

Lake Turkana's water pH and Total Dissolved solids in all sampling sites exceeded WHO maximum permissible limits of 6.5-8.5 and ≤ 600.0 mg/L respectively for drinking water. However, electrical conductivity and nitrates complied with WHO standard of 400.0 $\Omega cm^{-1}$ and 50.0 mg/L in all sampling sites.

The non-compliance of pH and TDS with WHO standards indicated that Lake Turkana's water was polluted and thus unsafe for human consumption. The phosphate levels exceeded USEPA limit of 0.024 mg/L, indicating eutrophication risk. Similarly, water lead and cadmium levels surpassed WHO standard of 0.01 mg/L and 0.003 mg/L in all sampling positions and two positions respectively, indicating the water was unsafe for human consumption.

**Conflict of interest**
The author declares no conflict of interest.

## V. Acknowlegement

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