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RESEARCH ARTICLE

EVALUATION OF THE EFFECTS OF SALT CONCENTRATIONS ON THE THERMODYNAMIC PROPERTIES OF WATERS IN LAKE VICTORIA.

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Abstract

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The presence of different cations in water does affect thermodynamic properties differentiary. Lake Victoria has many inflows (rivers) emanating from an agricultural areas. Consequently, it is expected that the will harbor a huge amount of cations. This research was focused on the salt effects on the thermodynamic properties of the waters of Lake Victoria. Where the mean P^H of the wet season was acidic at 6.42± 0.11, close to neutral and exhibited little variability, thus showing high stability. Further observations were made on the $P^H$of the dry season which had mean of 6.53±0.28 in this research. A SAMSUNG refrigerator (Model SR-L727EV) was used for freezing and a HACH heater (Model 240vac) were used for boiling purposes. Digital thermometer (Model 4445001) was used for temperature logging throughout the experiments. Analysis of variance was carried out to determine any significant differences of the cations concentrations on the water samples and on whether the cations significantly affected melting (point depression, boiling point elevation and vapor pressure deficit. It also was observed that cation concentration was significantly different and that direct addition of similar molar concentrations (0.2 moles) of the cations affected melting point, boiling point and vapor pressure significantly and differentially. Correlation models were developed that can be used to predict the effect of salt addition on thermodynamic properties.

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Introduction:-

Natural and anthropogenic activities in a given region largely determine the quality of surface[1] . Both of the said activities results in the water being polluted. Pollution is any chemical, physical or biological change in the quality of water that has a harmful effect on any living thing that drinks or uses or lives (in) it. If humans beings and animals drink polluted water it often has serious effects on their health. Water pollution can also make water unsuited for the desired use. Lake Victoria is shared between the three East African states and is in fact the largest tropical lake in the world with a surface area of 68,800 [3].

Lake Victoria is relatively shallow, with a mean depth of 40 m. The people of the East African countries have high ecological regard for Lake Victoria waters. It (L.Victoria) is used for transport, recreation, fisheries, and as a water supply for drinking, industry and agriculture. 80% of its water is due to direct precipitation [5] Average evaporation

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on the lake is between 2.0 and 2.2 metres (6.6 and 7.2 ft) per year almost double the precipitation of riparian areas [9].Lake Victoria is approximately 68800square kilometres (26,600 sq mi), [11]. In Africa, Lake Victoria is largest lake by area and the world's largest tropical lake. The water in Lake Victoria is neutral and is said to be slightly smaller than by Lake Superior in North America in terms of surface area.(Encyclopedia Britannica) In terms of volume, Lake Victoria is the world's ninth largest continental lake, containing about 2,750 cubic kilometres (2.23×10^9 acre·ft) of water[7]. Precipitation and streams are the major sources of the waters in Lake Victoria. The Kagera River is the largest river flowing into this lake, with its mouth on the lake's western shore. Lake Victoria is drained solely by the Nile River near Jinja, Uganda, on the lake's northern shore [11].

Objectives

To determine the salt concentrations in Lake Victoria waters.

Literature Review

According to lakepedia, Lake Victoria (or Victoria Nyanza in the Bantu language) is the largest lake in Africa compared to other lakes on the continent. It is the largest lake in Africa. The great latitude called the equator crosses this second largest freshwater lake in the world by surface area, after lake superior.

Lake Victoria receives its waters mainly from precipitation, which contributes about 80% of its water. Evaporation, measures between 2 and 2.2 meters (or 6.6 to 7.2 feet) every year. Lake Victoria is vulnerable to climate changes, because of its great surface area, its shallowness, and its limited inflow particularly from Sondu Miriu, Nyando, Nzoia, Gucha and Kagera rivers from Kenyan and Tanzania highlands respectively [10]

The main pollution culprits in lake Victoria include the discharge of raw sewage directly into the waters of the lake, industrial and domestic waste, and farm fertilizers and chemicals.

The area around the lake is one of the world's most densely populated rural areas. Some of the most important towns and cities around the lake include Kisumu (population: 410,000), Kisii (population: 200,000), and Homa bay (population: 56,000) in Kenya; Kampala (population: 1.66 million), Entebbe (population: 80,000), and Jinja (population: 73,000) in Uganda; Mwanza (population: 707,000), Musoma (population: 134,000), and Bukoba (population: 86,000) in Tanzania.

The many anthropogenic activities including factories and plants in these cities discharge their waste directly into lake Victoria's waters and the rivers that flow into it.

The raw sewage that is being discharged also increases eutrophication, which sustains the water hyacinth [4] Strange changes in thermodynamic properties impact indirectly upon biota through loss of supporting habitat such as coral reefs [6] by changing the solubility of oxygen and calcium carbonate (calcite or aragonite) in water, or by influencing the extent to which metal contaminants [8] [2] and other toxins are assimilated by physiological processes.

Water quality depends on the variations on the thermodynamic properties. This is because they influences several other parameters and can alter the physical and chemical properties of water. In this regard they should be accounted for when determining conductivity and salinity, oxidation reduction potential (ORP), pH, dissolved oxygen and other dissolved gas concentrations, density, metabolic rates and photosynthesis production, and compound toxicity.

Water has the highest dielectric constant of all substances except hydrogen peroxide (H_2O_2) and hydrogen cyanide (HCN). It has a high dissolving power because the water molecules reduce the forces of attraction between ions.
The force between ions (F) is coulombic and the dielectric constant (ε) reduces this force according to:

$$F = q1q2/r2\varepsilon ,$$

where q1 and q2 are the charges on two ions separated by a distance, r.
For water at 25°C, ε = 78.

The high heat capacity and heats of fusion and evaporation provide immense thermo stating capacity in the critical temperature range that accommodates most life (-50 to 100 °C).

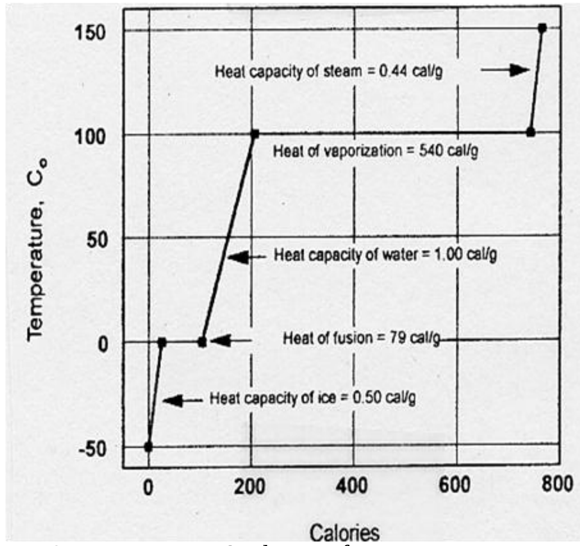

Figure 1:-Temperature & phases of water versus energy

Salts and any other polar compounds dissolve in water consequently increasing its density.
The effect is greater when the concentration of solute increases. However, dissolved salts lower the temperature at which water reaches its maximum density. This is because dissolved salts inhibit the tendency of water molecules to form direct bonds with other water molecules. Dissolved salts have the effect of making the water molecules cluster and become more ordered, thus harder to pull apart and evaporate.

Methodology:-

Six (6) locations were identified and marked along the river mouths of Sondu miriu, Nyamasaria, Kisiani, Kibos rivers mouths as known by the locals along the lake. From each sampling location, three (500mL) water samples were collected from the surface, between 5-10m deep. The samples were packed in plastic bottles and labeled (SI – S6) depending on the station and were stored in the refrigerator. Solutions of lower concentrations were prepared daily by a suitable dilution of the Lake Victoria waters. All tests were carried out at Kenya marine fisheries and research institute situated near Lake Victoria this enabled us to take advantageof the same meteorological conditions in the research site.

A SAMSUNG refrigerator (Model SR-L727EV) was be used for freezing and a HACH heater (Model 240vac) were used for boiling purposes. A HACH digital thermometer (Model 4445001) was used for temperature logging throughout the experiments. A Portable WTW Multi-meter (Model Profiline 197i) was used for the determination of the electrical conductivity (EC) and total dissolved solids (TDS). Other data were acquired from the national meteorological organization50ml of the water sample were measured into a beaker followed by addition of 5ml of conc. HNO_3. Then solution was slowly boiled in a hot plate until the volume reduced to 10-20 ml.

The contents were the Transferred by filtering into a 50ML volumetric flask and the filter paper washed three times with deionized water. Distilled water was added to the mark and the sample was ready for AAS analysis.

For each element, three standards were identified for calibration of the curve for analysis.

In addition, for pH readings, no sample preparation was required, only calibration of the pH heater was done then the samples were read.

Freezing Point Temperature

Temperature Probe was connected to the Vernier computer interface. The computer was prepared for data collection by opening the file “17 Freezing Ocean Water” from the *Earth Science with Vernier* folder. A 400 mL beaker was 1/3 full filled with ice, followed with 100 mL of water as shown in Figure 2. 5 mL of fresh water was put into a test tube and a utility clamp was used to fasten the test tube to a ring stand. The test tube was clamped above the water bath and the Temperature Probe was placed into the water inside the test tube. When everything was ready, data collection was started. Then the test tube was lowered into the ice-water bath. Soon after lowering the test tube, 5 spoons of salt was added to the beaker and stirred with a spoon continuously to stir the ice-water bath. Slightly, but continuously, the probe was moved during the first 10 minutes of data collection. The probe was kept in and not above the ice as it formed. When 10 minutes had gone by, moving the probe was stopped and allowed it to freeze into the ice. Stirring the ice-water bath was continued and more ice cubes was added as the original ice cubes got smaller. Observations were made and recorded as the water froze. When 15 minutes had passed, data collection was stopped. On the displayed graph, analysis was done on the flat part of the curve to determine the freezing temperature of fresh water.

The mouse pointer was moved to the beginning of the graph's flat part and Pressed and held down as it is dragged across the flat part to select it.

The Statistics button was clicked and the mean temperature value for the data selected was listed in the statistics box on the graph. This was the value for the freezing temperature of fresh water. The value was recorded it in the data table. This data was saved by selecting Store Latest Run from the Experiment menu. The Temperature Probe was not removed from the ice. The test tube was placed into a beaker of warm water to melt the ice, and the

Temperature Probe was removed

ΔT for the FP of each solution was calculated and added to the FP of pure water. The value was recorded in the data table. The difference between the measured value from the lab and the calculated value from the formula was calculated. This error was also recorded in the data table

Boiling Point Elevation

Boiling point apparatus were assembled (ring stand, ring, wire gauze, clamp, slotted rubber stopper, and thermometer). The thermometer was set up so that the temperatures above 100 ˚ C were easily read. The thermometer was supported in the middle of the liquid being heated, and that it was not rested on the bottom of the beaker in contact with the burner flame.

Water samples from the lake were measured separately and accurately (100ML) and labeled S1, S2, S3, S4, S5, and S6; for use in the boiling point study.

Using a graduated cylinder, exactly 100mL of distilled water (pure water) was measured and transferred to the 250 beaker. Heating the water was started bringing it to a gentle boil. When the water was gently boiling, its temperature was determined.

Note: The boiling point of water varies with atmospheric pressure, but should be very near 100 ˚ C. If the temperature as read on thermometer differs from 100˚C. This error should be kept in mind when reading the temperatures of the experimental solutions during the rest of this experiment. The flame was turned off and then very slowly and carefully 100ML of S1- sample was added the to a 250ML beaker. The flame was restarted bringing the solution to a gentle boil. The boiling point was recorded after making any adjustments based on error noted when measuring the temperature of the boiling distilled (pure) water. The procedure was repeated for S2, S3, S4, S5 and S6 samples.

P^H Of water from different sampling sites.

The P^H of water from five sites sampled in the inner winam gulf, Lake Victoria are presented in table 4.1, and appendix **2**. The mean P^H of the wet season was acidic at 6.42± 0.11, close to neutral and exhibited little variability, thus showing high stability. Similar observations were made on the P^H of the dry season which had mean of 6.53±0.28 .The latter P^H showed slightly higher variability compared to that of the wet season.

P^H Values of water samples during wet and dry seasons were graphically represented.

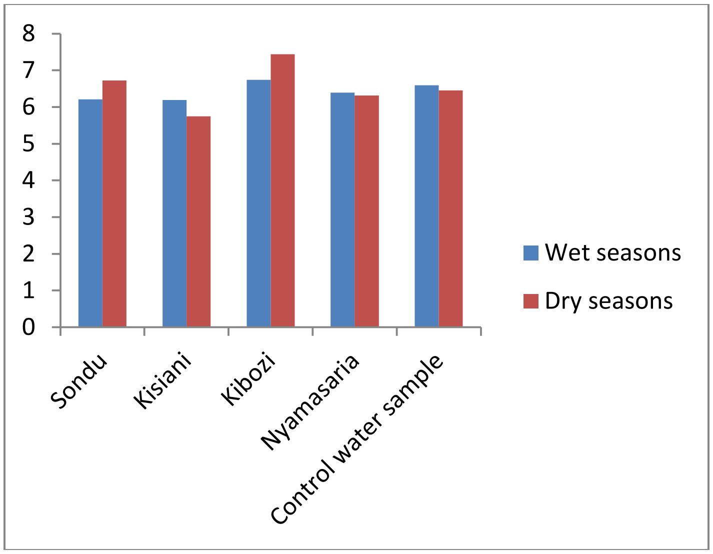

Figure 2:-Bar graph of pH values of water samples from sites during wet and dry seasons.

The P^H values from figure 8, during the wet season ranges from 6.21 to 6.59 whereas during the dry season it ranges from 5.75 to 7.44. If the pH of water is too high or too low, the aquatic organisms living within it will die. P^H can affect the solubility and toxicity of chemicals and heavy metals in the water. The majority of aquatic creatures prefer a pH range of 6.5 to 9.0, though some can live in water with pH levels outside of this range.

Concetrations of selected cations in water from different sampling sites.

The concentrations of selected cations in water samples (Na^+, K^+, Ca^{2+} Mg,$^{2+}$ Zn^{2+} and Pb^{2+}) are presented in table 1. The most dominant cation was K^+ followed by Na^+ at all sampling sites during the wet season.

Table 1:-Cations Descriptive Statistics for wet season

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Na^+	5	148.000	28.000	176.000	86.40000	27.027370	60.435037	3652.394
K^+	5	1012.500	31.500	1044.000	266.50000	195.149894	436.368429	190417.406
Ca^{2+}	5	9.400	4.200	13.600	8.06600	2.076942	4.644182	21.568
Mg^{2+}	5	21.05	10.85	31.90	18.3800	3.77924	8.45064	71.413
zn^{2+}	5	21.25	2.25	23.50	9.5400	3.62772	8.11183	65.802
Pb^{2+}	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The concentrations of the remaining cations, Ca^{2+} Mg,$^{2+}$ and Zn^{2+} were lower and variable at different sites. The cation Pb^{2+} occurred at undetectable at the different sampling sites. The variability of the cations: Na^+, K^+, Ca^{2+} Mg,$^{2+}$ and Zn^{2+} was significant in all cases since it was greater than 30% .

Moreover, the concentrations of selected cations in water samples (Na^+, K^+, Ca^{2+} Mg,$^{2+}$ Zn^{2+} and Pb^{2+}) during the dry season are presented in table 2. The most dominant cation was Na^+ followed by K^+at all sampling sites during the dry season.

Table 2:-Cations Descriptive Statistics for dry season

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Na^+	5	145.050	15.200	160.250	60.16000	26.009947	58.160010	3382.587

K^{+}	5	105.800	6.200	112.000	49.18000	18.708912	41.834400	1750.117
Ca^{2+}	5	10.140	5.360	15.500	10.13200	1.705762	3.814200	14.548
Mg^{2+}	5	30.56	2.59	33.15	15.0880	5.23382	11.70317	136.964
zn^{2+}	5	21.46	.04	21.50	8.7980	3.55661	7.95283	63.248
Pb^{2+}	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The concentrations of the remaining cations Ca^{2+} Mg,$^{2+}$ and Zn^{2+} were lower and variable at different sites. The cation Pb^{2+} occurred undetectable at the different sampling sites. The variability of the cations: Na^{+}, K^{+}, Ca^{2+} Mg,$^{2+}$ and Zn^{2+} was significant in all cases since it was greater than 30% .

Conclusion:-

The differences in boiling point, vapor pressure and freezing point depressions of the water samples from the river mouths that were sampled can be attributed to the different sizes of the catchments and the rivers themselves since the latter two determine the diversity and the of cations in water therefore, from the fore-going study salt concentration elevates boiling point and vapor pressure deficit of water while it depresses the freezing point.

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