International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.
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Vol. 37 No. 2 March 2023, pp. 236-244

Assessment Of Irrigation Water Quality Used In Kabuye Swamp, Gasabo District, Rwanda

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Abstract – The irrigated agriculture is dependent on an adequate water supply of usable quality. Water quality concerns have often been neglected because good quality water supplies have been plentiful and readily available. This situation is now changing in many areas. To avoid problems when using those poor-quality water supplies, it must be sound planning to ensure that the quality of water available is put to the best use (FAO, 1985). This study focused on assessment of irrigation water quality used in Kabuye swamp located in Gasabo District, Rwanda. The research aims to evaluate some physico-chemical parameters namely K^{+}, Ca^{2+}, Mg^{2+}, pH, electrical conductivity, and HCO_3^- along with Total Dissolved Solids (TDS) in order to assess the quality of irrigation water used and status of pollution in the irrigation reservoir and along the channel. Samples were collected once at three sampling sites during irrigation season along the irrigation channel, and then samples were transported to CAVM laboratory for analysis. Potassium was determined using flame photometer method while Bicarbonate, Magnesium and Calcium were determined using Titration method. It was observed that the values of Calcium, Magnesium and Potassium range from (33.60ppm to 54.40, 20.64ppm to 29.28ppm and 4ppm to 16.40ppm) respectively and increase from the top to tails end due to runoff nutrients. They are suited to the rice according to FAO, 1985.The pH, ECw and TDS fall in range of 6.71 to 6.92, 18.50µs/cm to 30.47µs/cm and 304.31ppm to 448.11ppm respectively that have no effect for rice. The content of Bicarbonate is high and ranges from 14.03ppm up to 38.73ppm which is not suitable for irrigation water. After water analysis the results were presented with the help of the piper diagrams. So, the new researchers are recommended to take three samples in three times for every site in order to get good results.

Keywords – Swamp, Irrigation Water Quality and physico-chemical parameters

I. INTRODUCTION

The agriculture production system in Rwanda is characterized by small arable lands, with a familiar exploitation of 0.8 hectares (TRANSTEC, 2009). Total arable land in Rwanda is slightly above 1.5 million ha (52% of the total lands), 90 percent of which is found on hillsides. Rwanda's theoretical potential for irrigation amounts to only 11% of its cultivated area, indicating that irrigation alone could reduce poverty only for a minority of the population. This suggests that improving non-irrigated, purely rain fed cropping is imperative. In field rainwater management such as the various forms of conservation agriculture intended to increase effective rainfall, could help farmers to stabilize and even increase dry land crop yields (IFAD, 2008).

The irrigated agriculture is dependent on an adequate water supply of usable quality. Water quality concerns have often been neglected because good quality water supplies have been plentiful and readily available. This situation is now changing in many areas. To avoid problems when using those poor-quality water supplies, it must be sound planning to ensure that the quality of water available is put to the best use (FAO, 1985).

The irrigation master plan for Rwanda showed that Rwanda irrigates and moderate agriculture on 587.711 ha land including: 219.797 ha of marshland potential, 153.534 ha of hillside domains, and 179.954ha of river and lake pumping domains and

36.432ha of ground resources (MINAGRI, 2011).

All irrigation waters contain some dissolved salts. Dissolved salts are present because some chemical elements have a strong attraction for water and a relatively weak attraction for other elements. Two such chemical elements, for example, are sodium and chloride. The amounts of these elements contained in water must be very high before sodium will combine with chloride to form the solid material sodium chloride, common table salt. The total amount and kinds of salts determine the suitability of the water for irrigation use. Water from some sources may contain so much salt that it is unsuitable for irrigation because of potential danger to the soil or crops. Irrigation water quality can best be determined by chemical laboratory analysis. (Simsek and Gunduz, 2007).

All water sources used in irrigation contains impurities and dissolved salts irrespective of whether they are surface or underground water. Water which can be considered good quality for household use may not ideal for irrigation. In agriculture, water quality is related to its effects on soil, crops and management necessary to compensate problems linked to water quality.

It is very important to note that not all problems of soil degradation like salinity, soil permeability, toxicity etc. can be related to irrigation water quality. Total salt concentration of irrigation waters should not be used as single criteria to prevent its use in irrigation. Even water with considerably high salt concentration can still be used for irrigation without endangering soil productivity, provided selected irrigation management could take into account all other factors affecting crop production (Ayers, 1985).

II. MATERIALS AND METHODS

2.1. Geographical description of the study area

The study was conducted in Gasabo District, the one among 3 Districts of Kigali City Province, exactly in Jabana Sector. Jabana Headquarters' and CORIKA offices are located at Kabuye at 10km from Kigali town on the right side of the main road Kigali to Gatuna near Kabuye Sugar works. The District borders in South the sector borders with Jali sector, in North with Masoro sector, in West with Kinyinya and Nduba sector, in East with Ntyaba sector. The study area is characterized essentially by a swamp where rice is grown by the cooperative CORIKA (RADA 2006). The said region is marked by the steep sloping hill, with Ntyaba Mountain, with a maximum altitude of 2134m and a minimum altitude of 1350m.

2.2. Materials, Tools and Equipment

The necessary materials and tools were used in order to achieve the objective of this research are below according to their different uses in the area under study; Na^+, Ca^{2+}, K^+, Mg^{2+}, Cl^-, HCO_3^-, ECw, and pH were analyzed in CAVM Laboratory, the samples were collected using the PVC bottles, the computer's software such MS Excel for analyzing the data. The table below summarizes the equipment, methods and reagents used during laboratory analysis.

No	Parameter	Equipment	Methods	Reagents
1	pH	Microprocessor pH-meter	Potentiometric	-
2	ECw	Beakers	Conductivity Meter (la Motte CDS conductivity)	-
3	Ca^{2+}	Porcelain dish, some volumetric flasks, burette and electronic balance.	Complexometric method, Titration of sample against EDTA solution	EDTA0.1N, Triethanolamine, NH_4NH_3Cl, Eriochrome BT indicator
4	Mg^{2+}	Porcelain dish, some volumetric flasks, burette and electronic balance.	Complexometric method, Titration of sample against EDTA solution	EDTA0.1N, Triethanolamine, NH_4NH_3Cl, Eriochrome BT indicator
5	K^+	some beakers Flame photometer, some volumetric	Flame photometer method	-

		flasks,		
6	HCO_3	Porcelain, burette and electronic balance	Simple acidimetric titration method	-Phenolphthalein indicator: 0.25 percent solution in 60 percent ethyl alcohol. -Methyl orange indicator: 0.5 percent solution in 95 percent alcohol. -Standard sulphuric acid (0.01M).
7	TDS	Oven at 105°C	Gravimetric method	-

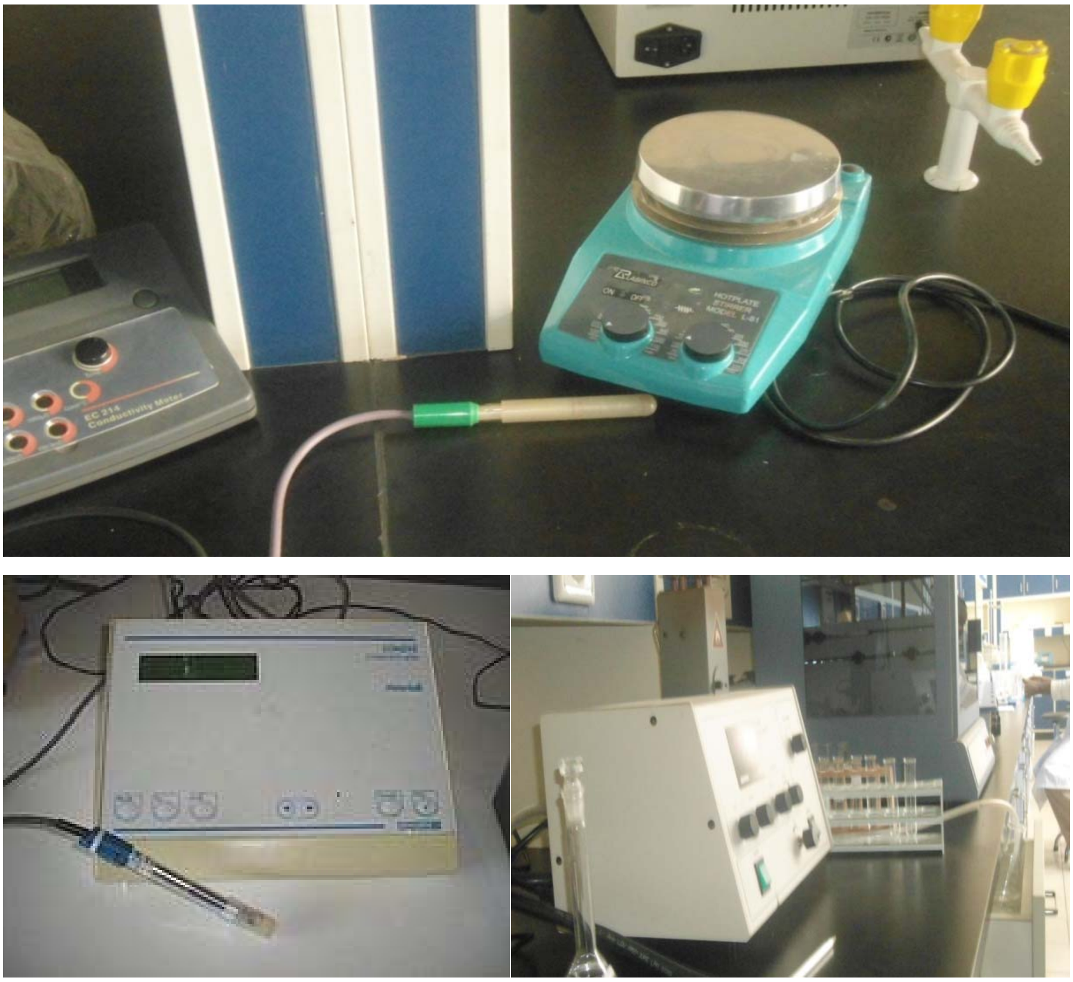

Figure 1: Common equipment used in Laboratory

2.3. Water sampling

The water sampling was carried out once during the irrigation season. For the purpose of this study 3 sampling sites were selected (Top, Middle and Tails end). The samples of water (1.5L) were collected in polyethylene containers from the swamp. In this study, samples were taken from the part where the water leaves the dam, to ensure that no mixing takes place with tail waters or runoff from the irrigated fields, in the center of irrigation canal, the second samples were taken at 1/3 of swamp and then the last was taken at 2/3 of swamp along the main channel, as long as this was possible from its means of length in order to know the quality of water used at the top, middle and at the tails end of the swamp, samples were stored in refrigerator (at 4°C), in the dark until chemical analysis that followed immediately after each sampling.

The sampling and analytical protocols used were in accordance with Standards Methods for the Examination of Water and Wastewater. It is important that the samples must represent the water source and special care may be needed to ensure that.To get good results, for each sample and for each parameter two test were done and was found the average of two results. Samples brought to the laboratories were analyzed without delay to prevent biological transformation.

2.4. Data analysis

The samples were analyzed for seven parameters which were Electrical conductivity (ECw), Calcium, Magnesium, Potassium, Bicarbonate, Total Dissolved Solids (TDS), and Potential Hydrogen (pH) using standard procedures recommended by FAO ,1985 and (APHA: AWWA: WEF, (1998). After determining field parameters (ECw, P^{H}), all the samples were kept in the dark at a cool temperature before being transported to a laboratory for quantification of other parameters (Calcium, Magnesium, Potassium, Bicarbonate).

In the laboratory, all the samples were kept in a refrigerator at a temperature below 4^{0}C. The procedures of the analysis were based on Sri Lankan standard. The Calcium and Magnesium content were determined by Titration method using Versenate EDTA, Potassium content was determined by using a flame photometer method. Electrical conductivity (ECw) and total alkalinity were measured by standard electrochemical methods. Bicarbonates, their estimation is based on simple acidimetric titration (Richards, 1954) using different indicators that work in the alkaline (higher than 8.2) or acidic pH range (lower than 6.0).

III. Resultats And Discussion

The three samples at different sampling sites across command area of the Dam were taken once for analysis and the obtained results are compared to the FAO standards requirement for irrigation water quality.

3.1. Results for Electrical conductivity and total dissolved solids

The electrical conductivity of Kabuye swamp irrigation water fall in range of 18.5µs/cm to 30.7µs/cm and the TDS has the range of 304.31ppm-448.11ppm (Fig2&Fig3) respectively. As the concentration of dissolved salts increases from the top to the tails end, the Electrical conductivity increases as the concentration of dissolved salts increases (Fig2). The high TDS at the top is due to discharges from different areas and reduced to the tails end while the discharges reduced (Fig 3).

According to the FAO, 1985 standards (0 to 750µs/cm for ECw and 0 to 2000ppm for TDS), the ECw and TDS water content of Kabuye swamp irrigation water (Figures 2 and 3) are good and can not cause any problems to the plants.

According to Bauder and Waskom, 2011 (ECw<770ppm for rice) and according to FAO, 1985, this water is suitable for rice because non-saline water (ECw= <0.7 dS/m).

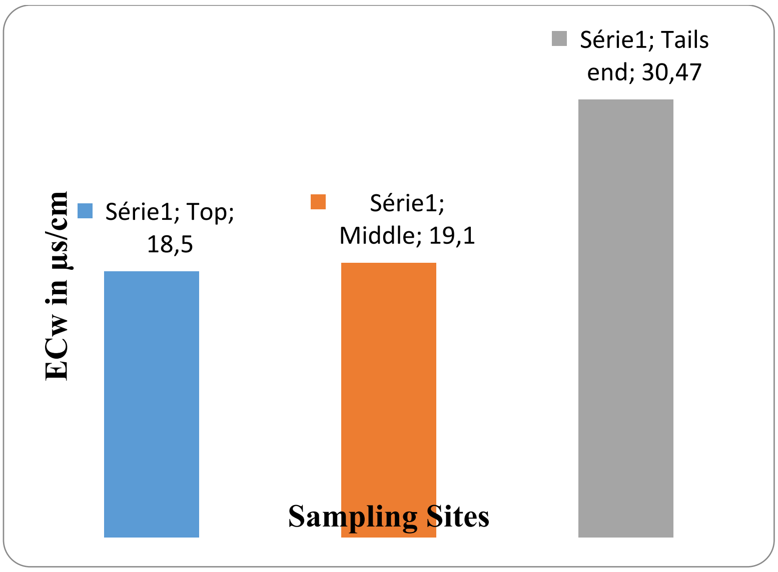

Figure 1: Results presentation of ECw

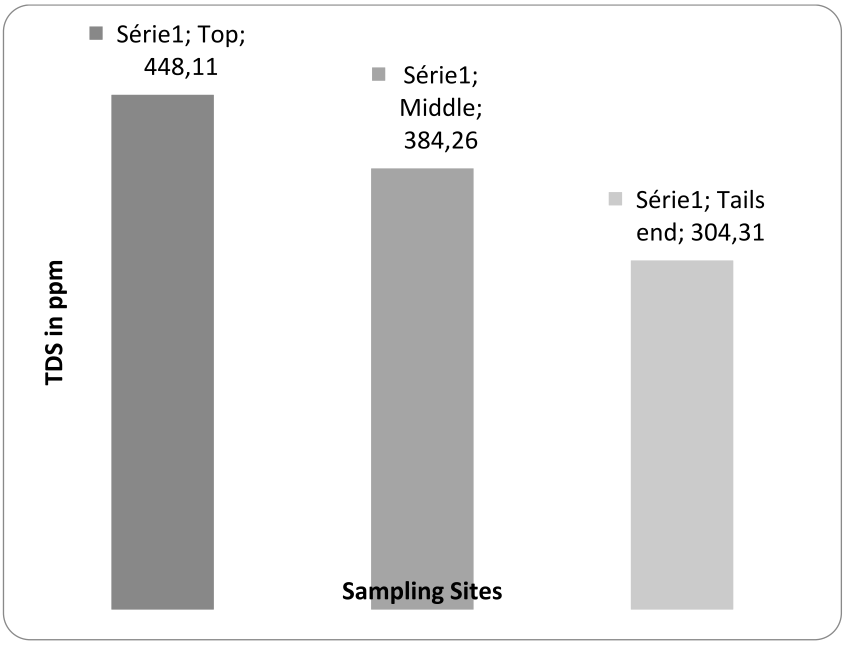

Figure 2: Results presentation of TDS

3.2. Result for Potential of hydrogen

Referring to the pH of Kabuye swamp irrigation water the hydrogen potential increases from the top to the end tails (Figure 4); the normal range of pH for most plants, specifically for rice is 6.5-8.4 (FAO, 1985) and the pH range of water samples is 6.71-6.92 that show the low pH in irrigation water used in Kabuye swamp.

The pH from the reservoir is little acidic, in the middle of irrigation channel and at the end tails of irrigation channels the water became good for irrigation due to decomposition of organic matter and due to dilution effect of rain water;

Referring to FAO standards, the pH content of water used for irrigation in Kabuye swamp is good for rice.

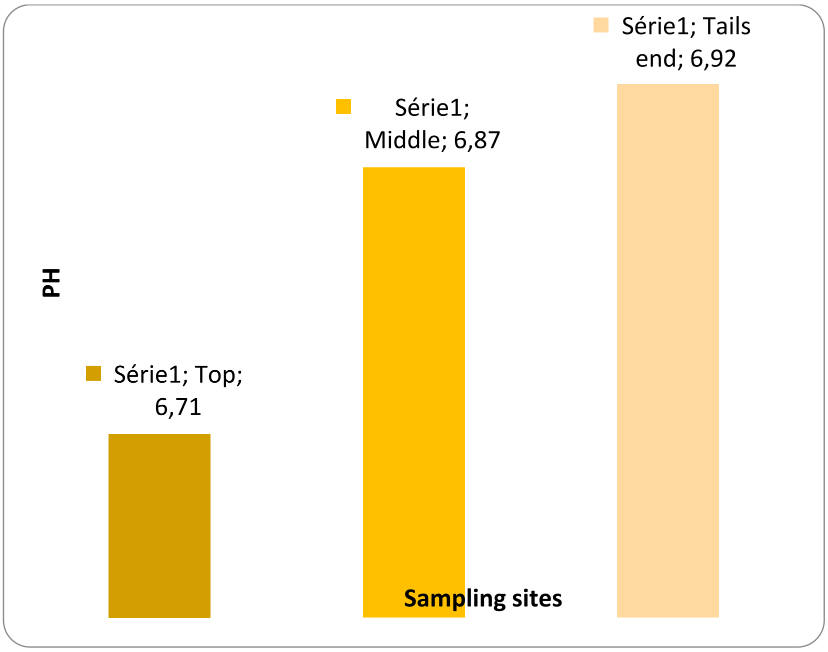

Figure 3: Results presentation of pH

3.3. Result for Potassium

According to the figure below (Figure 5), the results of Potassium are in range of 4ppm to 16.4ppm and the concentration increases from the top to the end tails because of runoff nutrients.

So, the FAO recommends the range of 0 to 78ppm for all plant including rice and this quantity of Potassium in Kabuye swamp is very low and suitable for rice.

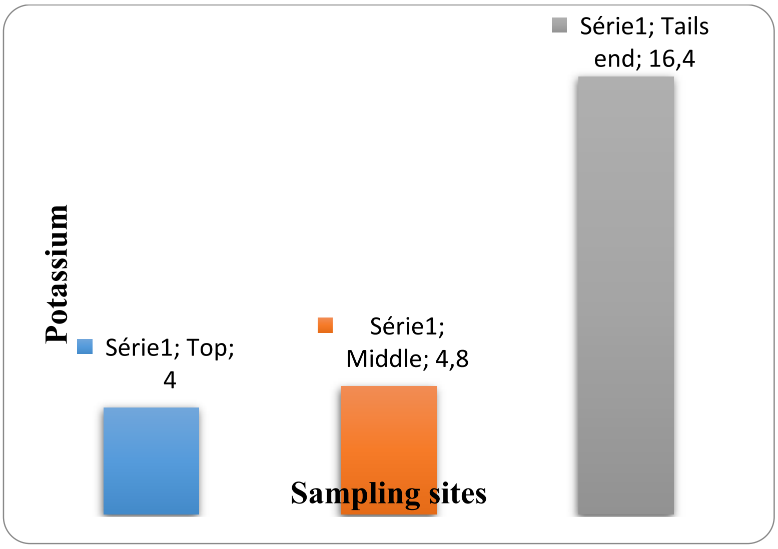

Figure 4: Results presentation of Potassium

3.4. Result for Calcium

At the top, the concentration is very low (33.6ppm) but in the middle and at the end tails, the concentration increases from the top to tails end normally, like Potassium and Magnesium, Calcium in water also increases due to runoff nutrients means that in Kabuye swamp the runoff nutrients increase from the top to the middle.

According to the FAO standards, 1985 and Bauder, 2011, the result of Calcium respects the irrigation standards for rice (<400ppm or <3meq/l).

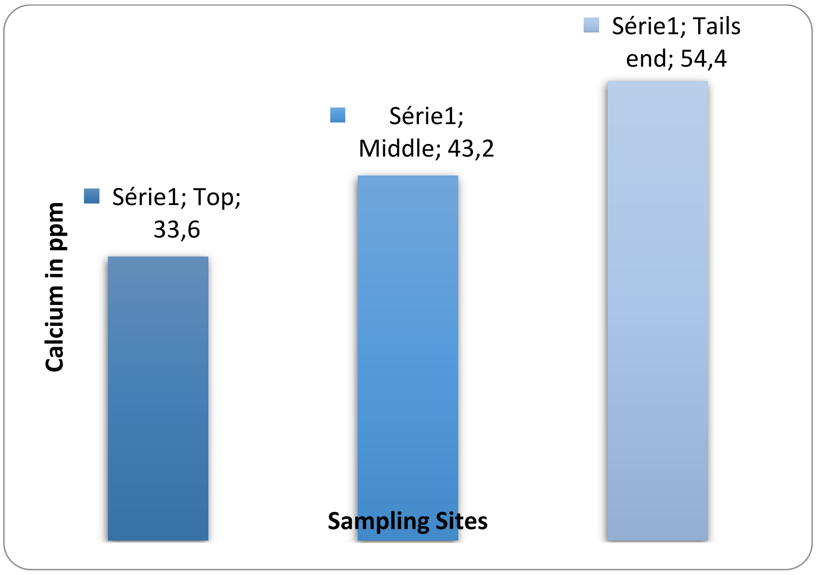

Figure 5: Results presentation of Ca^{2+}

3.5. Result for Magnesium

According to the figure below, the results of Magnesium are low compared to the FAO standards. this can not cause any problem to the plants. At the top, the concentration is very low (20.64ppm) but in the middle and at the end tails, the concentrations are 22.32ppn and 29.28 respectively, this increase is due to the augmentation of runoff nutrients. This water has no effect for rice according to FAO, 1985 (<60ppm)

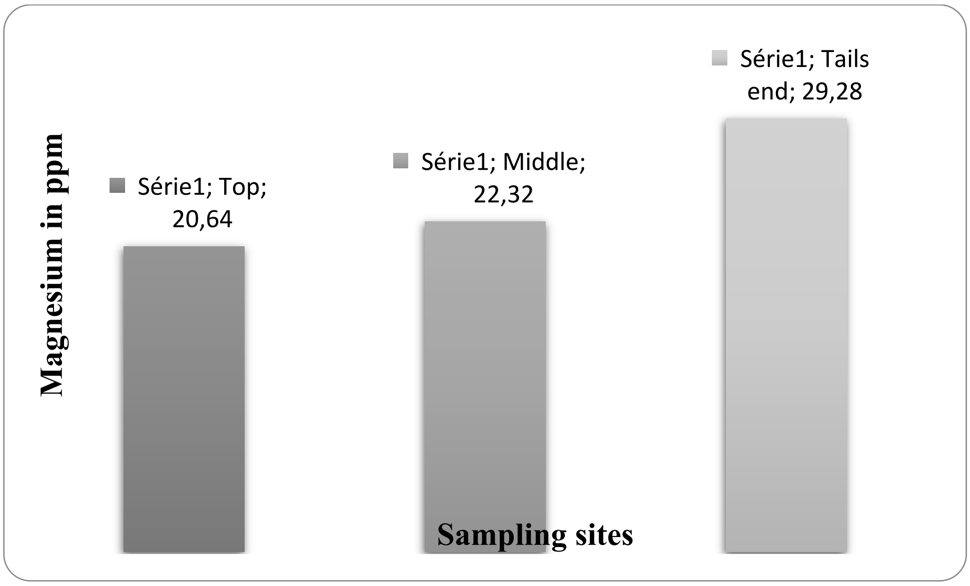

Figure 6: Results presentation of Mg^{2+}

3.6. Result for Bicarbonate

With reference to the figure below, the concentration of bicarbonate increases from the top(14.03ppm) to the tails end(38.73ppm). The concentration of bicarbonate of water used in Kabuye swamp is high and exceeds the standards set up by FAO,1985(8.5ppm), therefore, the water is not suitable for rice in terms of bicarbonate content.

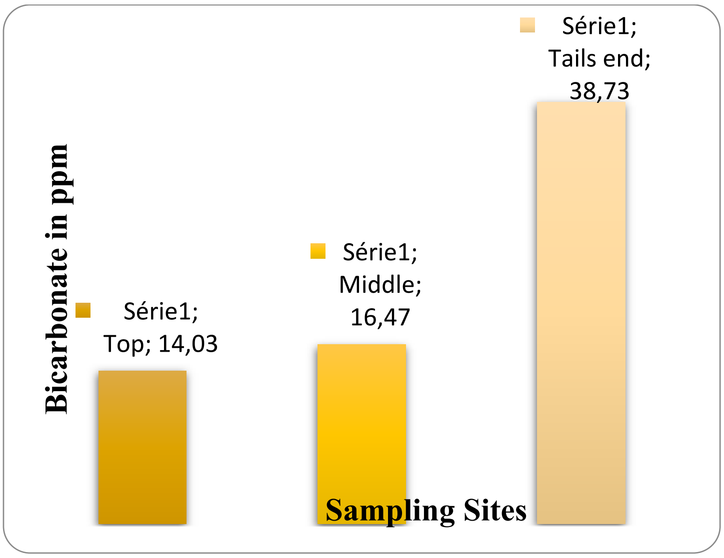

Figure 7: Results presentation of HCO_3^-

3.7. Interpretation of results

Regarding to classification of irrigation water quality, the results of research carried out in Kabuye swamp showed that, basing on the concentrations of Ca^{2+}, Mg^{2+}, K^+, ECw, pH and TDS, water of all sampling sites is suitable for irrigation. The exception was found for the concentration of bicarbonate which exceeds the FAO standards.

IV. Conclusion And Recommandation

Referring to the results obtained after analyzing the quality of irrigation water used in Kabuye swamp, the following conclusions are drawn: The Electrical conductivity of water used in Kabuye swamp falls in range of 19.10µs/cm to 30.47µs/cm and increases from the top to tails end proportionally to the concentration of dissolved salts, so that water is suitable to the rice (ECw<770ppm);The values found for PH range from 6.71 up to 6.92 and is suitable for irrigation because it includes in interval [6.5-8.4] suggested by FAO, The TDS of water used for irrigating Kabuye swamp falls in range of 304.31ppm up to 448.11ppm and is increasing from tails end to the top of the swamp due to discharges from different area; Low values of Ca^{2+}, Mg^{2+}, K^+ ions water where mentioned parameters classify water as fit for rice and increase due to runoff nutrients (Ca^{2+}<400ppm, Mg^{2+}<60ppm and K^+<78ppm), The high concentration of bicarbonate (HCO_3^-) found is not suitable for rice, hence, [HCO_3^-]>8.5ppm, according to FAO standards.

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