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PHYSICO-CHEMICAL PARAMETERS AND COMPARATIVE STUDIES ON GROUND WATER IN SONGEA, TANZANIA

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ABSTRACT

A series of water analysis planned in order to generate a valid database of water at possible locations, based on the physicochemical and microbiology parameters. In these planned experimental series, first sample of water collected from the ground water in the Ruhuwiko region of Songea district, Tanzania. The main objective is to analyze the ground water as obtained from the tap water for physicochemical features like water temperature, transparency, total suspended solids, total dissolved solids, pH, dissolved oxygen, total alkalinity, hardness, BOD, mineral studies, etc. Though these are the preliminary investigation parameters, the study also aimed to understand the influence of sedimentation of solids and dust particles deposited in the ground water and the impact of runoff rainwater. This paper present the initial results of the above-mentioned parameters obtained for a period of two months, to represent the scientific outline of the ground water in the selected location.

KEY WORDS: Physico-chemical characteristics, Electrical conductivity, Minerals, BOD and COD.

I. INTRODUCTION

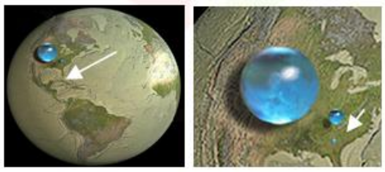

Fig. 1(a) Fig. 1(b)

Fig. 1 (a) and (b) Schematic illustration of water available in a particular location [2].

Water, the divine blessing of nature that holds the biosphere to flow smoothly with respect to all the creatures including human. Though the human force know, life is impossible without water, humans seldom realize it to handle water in the way it had to be, so that it is not becoming useless. The access of water assumed granted resulted in a colossal damage to the water resources and this cumulative impact reflected in the ecosystem and environment. The lines, "*Water, water everywhere, Nor any drop to drink*", is the words of Samuel Taylor Coleridge in his poem, "*The Rime of the Ancient Mariner*" when he was in the middle of the sea. Time is not so far that, these lines could have its application in almost all the water resources presently available, because of hypersonic speed of pollution of water bodies. Among the water bodies, ground water is gifted and granted source of water in earth to that particular biosphere [1]. A representation from the United States Geographical Survey (USGS) shows how available water in a particular location as compared to the water available globally with Georgia as a model site [figure 1(a)] [2]. The same has been expanded [figure 2(a)] so that, the three representations, in which the bigger one represent all the available water mostly oceans [2]. The smaller one illustrate the liquid fresh water and the tiny pixel represent the lakes and river [2]. If similar database generated for all the experimental locations then it is possible to create awareness on the actual availability of potable water as compared to the global source and it will create a positive impact on respecting and responding to water preservation and conservation measures.

Groundwater is the evergreen and sustaining ecosystem that provide river bases flow in dry season, spring flows and soaks or seeps. Groundwater supports productive wetlands and other terrestrial vegetation. If properly protected, developed, managed and monitored, groundwater can help in solving the water crisis in many countries. Although the global fresh water in our planet is about 1500 million cubic kilometers,[3] most of it is not fit for potable use as it contains salt and other unwanted substances beyond the permissible limit. In recent years, the total amount of fresh water available in our planet roughly estimated as around 84.4 million cubic kilometers. Rapid population growth, ever increasing living standards; wide spheres of human activities and industrialization have resulted in a great demand of good quality of water, on the other hand, pollution of water resources is also increasing steadily [3]. Ground water quality largely controlled by geology [4].

Tanzania, located in east Africa, bordered by Kenya, Uganda, Mozambique and the Indian Ocean with a total land area of 945,000 sq. km (including Mafia, Pemba and Zanzibar). The terrain consists of lowland plains along the coast, a central plateau (1000-1500 m) and highlands over 2000 m in the north and south. Kilimanjaro, the highest mountain in Africa, lies in northeastern Tanzania with an altitude of 5895 m. Lakes Tanganyika and Victoria lie partially within Tanzania, along the western and northern borders respectively. Climate varies from tropical in coastal areas to temperate in the highlands and semi-arid in the central plateau. Annual rainfall ranges from 2500-3000 mm on the flanks of Mount Meru in the north, to 1000 mm at the coast, down to 550 mm in the central plateau (Dodoma). Highest points in northern Tanzania are snow-covered. Mean annual temperature in the Mount Meru area (north) is 19ºC (range 12-28ºC), but increases to

26ºC at the coast [4]. The geological features of rocks of Songea region, within the Ruhuhu basin observed to be Late Carboniferous to Middle [5]. This report provides a detailed insight of the geological features [5]. A combination of electromagnetic (EM), seismic and vertical electric sounding (VES) carried out revealed the geology of area around Songea is dominantly a cover of superficial deposits of quaternary age overlying granites and granitic gneisses of the Basement complex [6]. Tanzania endowed with enormous natural water resources, yet receipt of clean and hygiene water throughout the country is a challenge [7]. As on 2017, twenty urban water supply authorities functioning [7]. Out of these twenty, Arusha, Songea and Tanga were the authorities to supply water continuously [7].

The problems relating to water attract the attention to the regency for investigating causes and suggest remedies in a bid to prepare future action for maintenance of portable waters and related developmental issues. Fresh water is a finite resource, essential for agriculture, industry and even human existence, without adequate quantity and quality of fresh water, sustainable development will not be possible [8, 9]. Lakes are considered as the largest water bodies within land [10], the maintenance of a healthy aquatic ecosystem is dependent on the physico-chemical properties of water and the biological diversity. Nowadays, the ecology of reservoirs is under stressed condition due to fast pace of urbanization, deforestation, cultural practices and agriculture. Fresh water resource is disappearing day-by-day at a faster rate and deterioration of water quality is has become a global problem [11-13]. The government of Tanzania report suggests that different parts of Tanzania experience different challenges with respect to water qualities. Few of them are; nature of the parent rocks in a particular geography, climatic effects, stream flow, over extraction of ground water, inadequate recharge of aquifers, etc. These effects aggravated due to the uneven rainfall in that region. Either one or more effect may or may not influence the ground water source in Tanzania [14]. It is difficult to understand biological phenomena fully without the knowledge of water chemistry as the limnobiological and limnochemical components of the ecosystem are involved. Physicochemical and microbiological characteristics may describe the quality of water. The main purpose of analyzing physical, chemical and microbiological characteristics of water is to determine its nutritional status [10-13].

The present study provide an outline of the information on physicochemical and mineral parameters of the ground water at Songea with an objective to record the changes in the quality of waters for a period of two months (October and November 2014). This study also helpful estimating to witness the impact of various physicochemical and mineral parameters on the ground water of the selected region.

II. STUDY AREA

Figure 2. Map of Songea [15]

The experimental location was St. Joseph University College of Agricultural Sciences and Technology, Songea Campus, Tanzania. As none of the classified, environmental disturbing, endangering and / or protected activities involved, no specific approval required. Songea is in the Ruvuma region, situated in the Southern part of Tanzania. The region extends between latitudes 90 35' to 110 45' South of Equator and longitudes 340 35' to 380 10' Meridian. Ruvuma region borders the Republic of Mozambique in the South, Lake Nyasa in the West and Iringa in the North-North East and bordered by Mtwara Region to the West. The lowlands in the Eastern part of the region are 300 meters above sea level while the Northern and Western parts of Lukumburu and Matengo mountains rise to the level of 2,000 meters above sea level. Out of the total population, 70 % of labor forces in Songea are engaged in agriculture [15]. The location map of Songea (figure 2) [15] and the experimental location as obtained from the google resources presented in the figures (figures 3a – 3d) [16]. As the actual photograph reserved, common and available google coordinates of the experimental location shared. The circle in the figures (3c & 3d) indicates the tap water source [16].

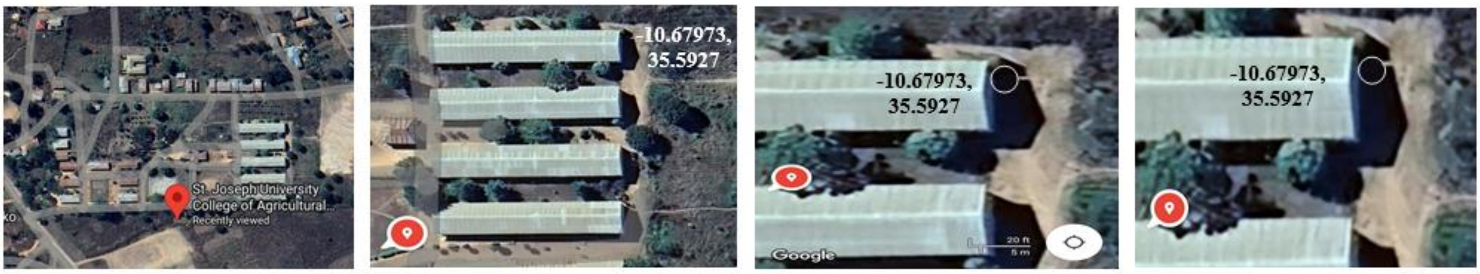

Fig. 3a Fig. 3b Fig. 3c Fig. 3d

Figure 3a -3d Experimental location at the St Joseph University College of Agricultural Sciences and Technology

The climate of Songea, Ruvuma region has a moderate temperature averaging 23°C depending on altitude and season. The months of June, July and August are cold with the temperature dropping to 13°C. October and November are the hottest months with an average temperature of 30° C. Annual rainfall of Songea estimated to be 65 mm but rainfall varies substantially, seasonally and geographically. The monsoon dominates the annual weather cycling of ground water at Songea in December.

III. MATERIALS AND METHODS

Physico-chemical Characteristics

For the present study, water samples collected from the ground water as obtained from the tap water at the St. Joseph University College of Agriculture Sciences and Technology, Songea, for a period of two months starting from October 2014 to November 2014. To maintain uniformity water sampling collection fixed from 10:00 to 11:00 hours. The physical characterization include temperature, color, conductivity, turbidity, total dissolved solids (TDS), total suspended solids (TSS) and total solids (TS). The chemical analysis include alkalinity, hardness, pH, dissolved oxygen (DO), minerals (Ca, Mg, Fe, Na, Cl_2, SO_4, Si, PO_4, NO_3, Total organic carbon, K), chemical oxygen demand (COD) and biological oxygen demand (BOD). The samples collected and pretreated in the field to fix the samples then immediately brought to the laboratory for an on-spot physical and chemical analysis of various parameters as per the standard methods [17-19].

V. RESULTS AND DISCUSSIONS

The nutrient content and the data of the seasonal variations in the physico chemical parameters of the Ground water of Songea for a period of two months (October 2014 to November 2014) presented in the Table I and II. The months October and November 2014 henceforth referred as 'Test Period'

Table I: Variations in the nutrient content of the Ground Water of Songea during the test period

Period	Ca	Mg	Fe	Na	Cl	SO_4	Si	PO_4	NO_3	Organic Carbon	K
October 2014	325	125	0.08	58	25	35	0.12	31	25	75	35
November 2014	375	170	0.15	64	26	35	0.18	34	29	83	41
Mean Values	350	147.5	0.115	61	25.5	35	0.15	32.5	27	79	38

Table II: Physicochemical characteristics of Ground water for the period of (Oct and Nov 2014)

Properties ↓, Period →	October 2014	November 2014
Temperature (Degree Celsius)	30	28
Colour	C	C
Turbidity (N.T.U)	5	4
Electrical Conductivity (m mho)	150	165
Suspended Solids (mg/L)	78	85
Dissolved Solids (mg/L)	650	720
Total Solids (mg/L)	728	805
pH	6.5	6.2
DO (mg/L)	4	5
BOD	32	45
Total Hardness (mg/L)	450	545

During the test period, temperature difference was minor and the temperature during the night reduced to 15 – 18 °C. The water sample is colorless during most of the days of experimentation; this may be due to the less turbidity or turbidity at an acceptable limit. From the above tables (Table I and II), as compared to the month of October 2014, November 2014 have a slight variation but in the higher side for almost all the parameters. This may be due to the rainfall during the month of November 2014. As the ground water sources are available within a depth of less than 10 m [4] in Tanzania, a bit lesser in the Songea region, a moderate rainfall for a shorter period have chances to influence water line connecting the ground water sources. A uniform raise in the observed values indicates that the ground water source recharged due to the incidental rainfall (in this study the factors due to the influence of the rainfall were not observed and hence it is not included).

The comparative physico-chemical parameters provided in the Figure 3. Similar trend that is, an increase in the values of all the physico-chemical parameters observed.

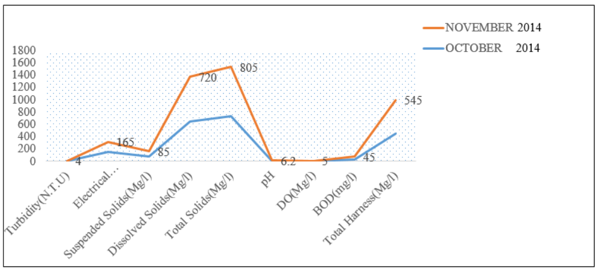

Figure 4. Comparative Physico-chemical parameters of water samples during the test period

The turbidity value was 5N.T.U (figure 4) in the month of November. This could be due to the lack of run-off area at the test point area, which is a human active area. During raining, more chances for the flow of large volume of fast flow of rainwater. Turbidity of ground water in Songea is due to the geographical features and natural sources that can include erosion from upland areas, Amriparian cause, stream bank, and stream channel areas passing in to the ground water. Another factor could be the human interaction during the month of November as they carry out the ablution activities in the test area or nearby water sources.

The electrical conductivity value of the water was ranging from 150 to 165 µS cm^{-1} during the test period. Electrical conductivity of water directly related to the concentration of dissolved ionized salts in the water. The higher value in the second part of the test period (November 2014) is higher indicates the increase of dissolved ionized salts [20]. The electrical conductivity increase shows the increase in concentration of ionized substance and/or other mineral contamination. This fact supported by the TDS and TS increase with an increase in hardness values for the experimental period. This may be also due to the rock water interaction when the water is recharging. The increase in the value of BOD and COD indicates the increase in the pollution. This might be due to the organic matter decomposition, floating debris, runoff, etc., [21-24]. This factor confirmed from the increase in mineral content observed from the mineral analysis (figure 5). The pH value of the sample water had a slight increased from 6.2 to 6.5. Various factors that attribute to the increase in pH are increase in pollutants, contaminants, algal growth, nature of bedrock and soil, etc. The higher pH (6.5) during the month of November indicates the maximum level of dissolved solids and the acidic condition of the water bodies. This might be due to agricultural runoff, variation in nutrients level, temperature and may be due to microbial activity [25].

The minimum dissolved oxygen value measured as chemical oxygen demand (COD) recorded as 5 mg/l in the month of November and the maximum value of dissolved oxygen 4 mg/l recorded in the month of October (figure 4). The increase in COD may also due to the decay of plant matter, increase of soluble organic compounds or accumulation of organic matter in the nearby areas that indicates the pollution of the source [26]. A similar observation reported that under natural condition the running water typically contains a relatively high concentration of dissolved oxygen tending towards saturation [27]. This supported by the increase in the organic carbon (figure 5).

Similarly, an increase in biological oxygen demand (BOD) confirms (figure 4 and table 2) dissolving of contaminated organic matter in the water line or in the soil which is close to the water source [26, 27].

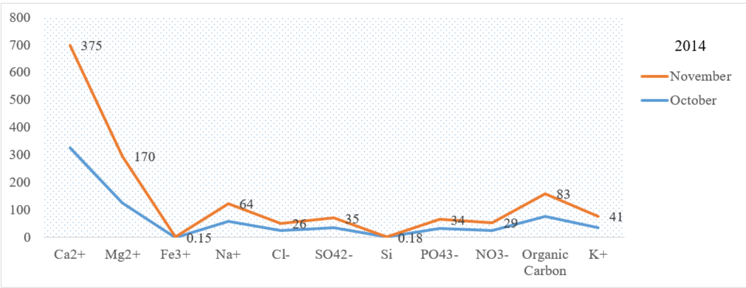

Figure 5. Comparative Mineral Content of water samples during the test period

A comparative account of mineral content of the water samples during the test period presented in figure 5. Similar to the physico-chemical parameters (Table 1 & 2, figure 4), an increase in the mineral content observed for the month of November 2014. Around 14 % of calcium level found to increase in a short period of one month as compared to October and November 2014. This increase attributed to the hydrogeological feature of the region [4-6] as well as due to the presence of rocks that leaches to the water during rainy season. The value of iron was ranging from 0.08 mg/l to 0.15 mg/l may be due to the corrosion effect of the pipeline as the test sample is from the tap water source. The value of chlorides ranging from 25 mg/l to 26 mg/l, minimum amount was in the month of October and maximum value was in the month of November. Chloride is a pollution indicating parameters and it is responsible for the salty taste of water, and this indicates that the water is moving towards pollution. The direct correlation between chloride concentration and pollution load [28]. The higher value of (35mg/l, figure 5) may be due to the increase in the sulfur-oxidizing bacteria during a particular season or due to the atmospheric deposits depending on the wind velocity. However, further studies in this direction can bring out the correlation.

The value of silicate (figure 5) ranging from 0.12 mg/l to 0.18 mg/l, minimum amount was at the month of October and maximum value was at the month of November, but it is within the permissible limit [29]. The value of phosphate ranging from 31 mg/l to 34 mg/l, minimum amount was at the month of October and maximum value was at the month of November. The value of nitrates ranging from 25 mg/l to 29 mg/l, minimum amount was at the month October of and maximum value was at the month of November. The higher amount of carbonate and bicarbonate observed which might be due to the combination of excess carbon dioxide with mono carbonate forming bicarbonate. As compared to the month of October and November 2014, later shows a slight increase in the presence of trace elements. This may be due to incidental and irregular rainfall in the region that influenced the characteristic features. The dissolved salt content in the form of Sulphate, Phosphate, Calcium, Iron and Sodium in the sample shows slight variation with respect to various national and international drinking water quality standards [30]. Nitrate is one of the several inorganic pollutants contributed by the nitrogenous fertilizers, organic manures, human and animal wastes [31].

The Piper diagram of the ground water sample analyzed presented (figure 6). The cation's triangle in piper diagram reveals that the Ca^{2+} ions ranging from 50 – 60 % mg/L, Mg^{2+} ions 40 – 50 % mg/L and Na^{+}, K^{+} ions range is 55 – 65 % mg/L. From the cationic triangle, the domination of calcium observed. In addition to this, the ranges shows lesser or absence of equilibrium of cations, so, the cationic inference may be "Calcium Dominant Type". The anion's triangle shows the Cl^{-} range as 30 – 40 %, SO_4^{2-} in the range 50 – 60 %, CO_3^{2-} & HCO_3^{-} in the range 40 – 50 %. From the piper diagram, the equilibrium between the anions observed. Therefore, from the anion triangle, anions are of "No Dominant Type". The overall projection based on the Piper diagram (figure 6), through the diamond plot confirms that the water sample analyzed from the St. Joseph's University College of Agricultural Sciences and Technology is of "Mixed Type" where "strong acid exceed week acid".

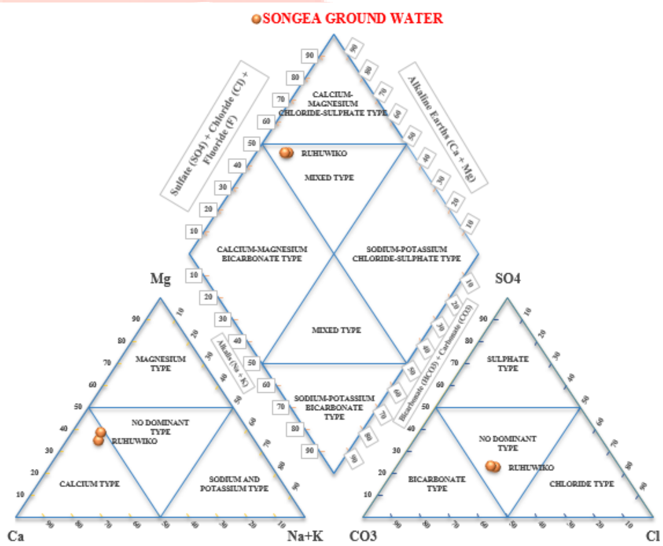

Figure 6. Piper Diagram of Ground Water Samples of Songea

In general, the potable water should adhere the standard [32] and should not contain the salts and other impurities beyond the permissible limits as per the international standards [33]. The level of dissolved oxygen in the acceptable limit can facilitate the healthy aquatic life, fish, etc.

VI. CONCLUSION

In the experimental area, the living population in Songea region are using the test area ground water as their major potable purpose including drinking in all the seasons throughout the year. This paper presents the first data on the quality of water available and utilized by the people in the Songea region of Tanzania. The values of the physico-chemical parameters indicates the safer level of the water available apart from minor variation. These investigations does not include microbial activity, rainfall and other advanced water characterization. However, this data is not representing the complete picture and scientific representation of the water in the area, but it can form the basis for the improvement of quality of water in the region. This study also alarms the rapid pollution around the selected water body. Certainly, these data will support the government and non-governmental organization for improving the quality of available in this region. In this aspect, authors feel grateful to present these findings.

VII. ACKNOWLEDGEMENT

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