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Physicochemical properties of rainwater quality of Calabar Municipality, S.E. Nigeria

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Abstract
Rainwater samples from two different stations, Government College, Ikot Ansa Calabar-Nigeia (GOVT) and Arab Construction Company, Atimbo Calabar-Nigeria (ARAB). Were collected during the raining season (June to December, 2017) and analyzed. Their pH (range 5.36 – 8.00), electrical conductivity (range 4.91 – 62.77 µs/cm), total dissolve solids (range 5.0 -56.67 mg/l) were immediately monitored within the next twenty four hours of sample collections using standard SEAM methods. The major ions such as Cl^-, SO_4^{2-}, NO_3^-, Na^+ NH_4^+ were analyzed using UV Spectrophotometer the results of the analysis were compared with the values provided by WHO guidelines in order to access the quality of rainwater. The samples of rainwater studied were completely free from considerable pollution and meet the WHO standard values.

Keywords: physicochemical parameters, rainwater quality, ions, WHO

1. Introduction
The activities of human have influenced the quality of rain water either directly or indirectly. Rain water quality gives the amount and types of dissolved or suspended materials in the water collected during rain fall, these materials constitute water pollutant which are dispersed in air medium. They may be solid, liquid or gases. The predominant gases are CO_2, O_2, NO_2 and SO_2 which when dissolve gives the acidity in rain water, a very dangerous occurrence that threatens both human and animal lives. The acid rain falling on soil or ground water affects agricultural production and pollutes drinking water. Acid rain also leaches metal such as Cd, Mn, Fe, As, Hg and Al from soil into water bodies like seas and Oceans [1].

1.1 Description of Study Area
Calabar is position between Latitude 4^0 and 7^0 north of the equator and between Longitude 80^o and 90^o east of Greenwich. The area is bordered in the east west of south by cross river, it expand from the coast to about 150 km inland and much of the area is under the influence of the sea. The climate of Calabar municipality is characterized by seasonal north-south movement of a zone of discontinuity which separates the continental air masses. Wet continental air mass brings about wet season which last from April to October whereas the Dry continental air mass brings about dry season which extends from December to February. November and March are Transitional months [2]. Although Calabar is in Niger Delta region of Nigeria, there is no flow station and no gas flaring in the area. The only oil company presence in the city is NNPC and North west Tank farm at Ekorinim. Though increase in the number of road unworthy vehicles and the associated traffic jams and other environmentally unsafe activities in the city has led to an increased emission of gaseous pollutants in Calabar [2, 3].

2. Methodology
2.1 Sample Collection Analysis
Rain water samples were collected directly from rain water in Calabar Municipality from two different station; one at Government College Ikot Ansa Calabar-Nigeria, labeled GOVT. and the other behind Arab Construction Company, Atimbo, Calabar-Nigeria, labeled ARAB. Rain water samples were collected monthly from June, 2017 to December, 2017. The sample of rain was collected in plastic bottles mounted on platform in an open space free from any interfering matter that could contaminate the rain water. A week prior to the day of collection of samples, the plastic bottles were carefully raised with de ionized water. The samples were analyzed using a standard methods SEAM, 2003 and APHA, 1998 [4, 5]. Described in it operative manual. The pH was determined with the aid of Lutron pH 201, TDS and conductivity were determined using HACH conductivity/TDS meter (model 44600.00). The nitrate (NO_3^-), sulphate (SO_4^{2-}) and ammonium (NH_4^+) ions concentrations were determined using HACH3000DREL UV Spectrophotometer.

3. Results and Discussion
Rainwater is an important component of hydrological cycle that plays significant role in the universal cycling of soluble chemicals in water. It cleansing the atmosphere by washing out pollutants from air and introducing them into surface water and soil where it affects the natural ecosystem. Rainwater samples collected from two stations in Calabar municipality were analyzed in order to determine the effect of pollution in air and results are summarized in Table 1.

3.1 Physical Parameters of Rainwater
The average monthly levels of pH, Conductivity, TDS, TSS and Concentration of Cl^-, SO_4^2, NO_3^-, Na^+ NH_4^+ in rain water samples during the period of study are shown in Figure 1-7.

3.1.1 pH
The concentration of anionic and cationic species causes alkalinity and acidity in rainwater. Ph is an important instrument for measuring the acidity of rainwater. Acidic pH illustrate the presence of strong acids while neutral or alkaline pH shows neutralization of acids by either.

Table 1: Physical parameters of Rainwater samples at Government college Ikot Ansa and Arab Construction Company Atimbo Calabar-Nigeria.

Parameters		June	July	August	September	October	November	December
GOVT	pH	5.36	6.44	6.27	6.29	6.71	6.41	7.63
	Cond.µs/cm	9.04	7.71	8.61	8.05	16.55	12.23	9.51
	TSSmg/l	0.00	0.12	0.23	0.01	0.01	0.01	0.00
	TDSmg/l	9.28	11.32	8.93	8.43	15.35	5.00	12.35
	Cl^- mg/l	19.64	15.76	25.71	40.55	48.13	56.23	49.99
	SO_4^{2-} mg/l	5.15	0.00	0.00	0.00	0.00	0.00	0.00
	NO_3^- mg/l	1.48	2.51	3.25	4.48	2.95	3.74	4.28
	Na^+mg/l	15.56	42.34	46.51	32.98	46.31	48.11	34.22
	NH_4^+ mg/l	2.40	1.43	0.99	0.46	0.36	0.53	1.20
ARAB	pH	7.96	8	7.92	6.77	6.62	6.6	6.93
	Cond.µs/cm	10.78	62.77	15.6	12.68	12.39	14.35	4.91
	TSSmg/l	0.00	0.01	0.06	0.00	0.00	0.00	0.00
	TDSmg/l	11.73	56.67	13.81	12.61	11.26	9.34	8.01
	Cl^- mg/l	23.21	38.87	32.56	44.61	93.64	73.48	66.35
	SO_4^{2-} mg/l	3.62	0.00	0.01	0.00	0.03	0.00	0.01
	NO_3^- mg/l	1.37	1.77	1.87	3.28	5.34	4.05	5.38
	Na^+mg/l	61.34	59.11	64.32	48.87	44.21	47.62	80.44
	NH_4^+ mg/l	2.8	2.56	0.18	0.65	0.44	0.91	2.49

Mineral dust or carbonate [6, 7]. The results shows that no acid rain was observed in the samples area, this may be as a result of the reaction of sulphuric and nitric acid absorbed in the atmosphere with alkaline carbonates [6].

3.1.2 Conductivity

Conductivity is the mean factor for determining the purity of water, it depends on the nature and concentration of ionized substances in the water. The conductivity of rainwater in the studied area were generally low with values ranging 4.91 to 62.77 µs/cm these values were lower than the WHO standard limit of 900 µs/cm for drinking water [10]. According to Moses *et al.* (2016) and Olowoyo *et al.* (2011) [8, 9], the low conductivity of rainwater indicates low atmospheric contamination with particulate matter. The results generally revealed good atmospheric condition of the sample studied area.

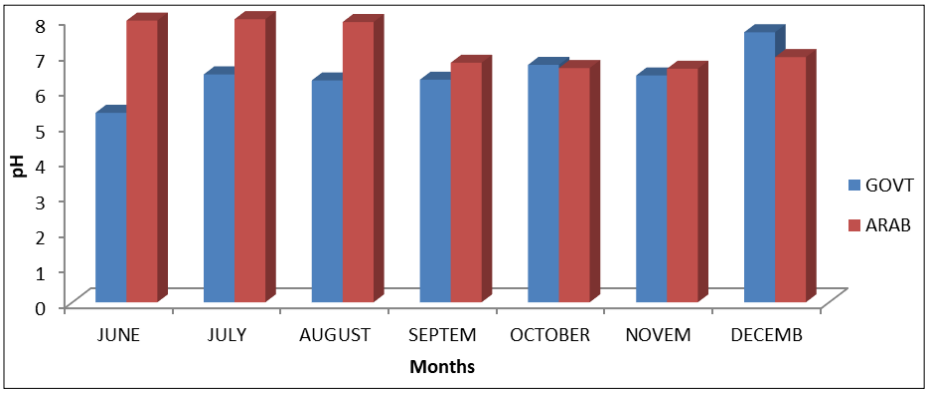

Fig 1: pH levels in the rainwater sample

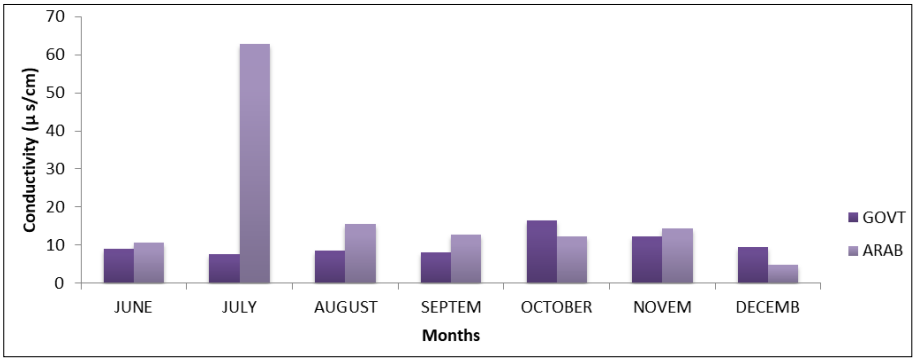

Fig 2: Electrical conductivity levels in rainwater sample

3.1.3 Total Dissolve Solid (TDS)

TDS are solids present in water in the dissolve form. This parameter is very considerable in describing the chemical constituents of water, according to Chughtai *et al*., 2014b [11]. The increase in TDS values reflect more suspended and dust particles in it. TDS of rainwater also depend on the quantity of rain fall. UNESCO stated that the TDS values between 0 to 2900 mg/l are suitable for all animals while

WHO, 2008 [10] limit for portable water was as 600 mg/l. The concentration range of the studied samples is between 5.00 to 56.5 mg/l. This shows that the rainwater samples in the two station is good and can be used for portable water.

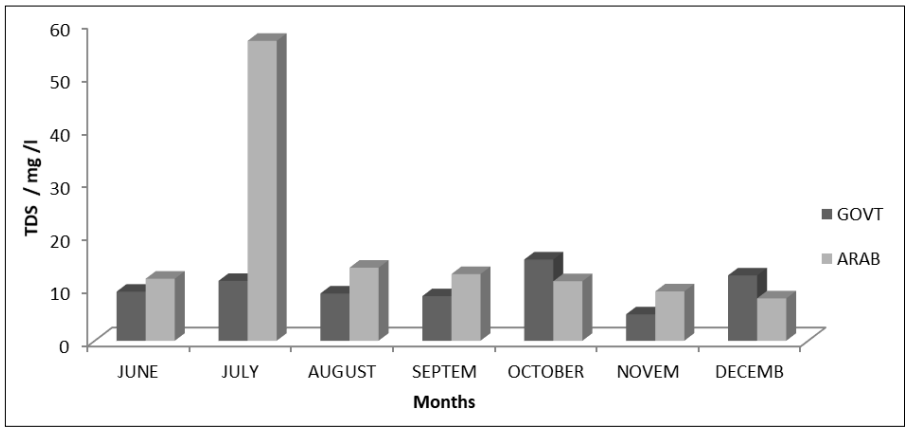

Fig 2: Concentration of total dissolve solids in rainwater samples.

3.2 Major Ions

Various amounts of major and minor ions are present in rainwater as mixed electrolytes. Some of these ions include: Na, Chloride, Sulphate, Nitrate and Ammonium, Na^+ and Cl^- in rainwater is seen as sea salt because of injection of seawater into the atmosphere cause by wave split. The water in the atmosphere disperse, leaving a solid aerosol particle, which is transported by winds until it is dissolved by rain. This causes the high concentrations in Na^+ and Cl^- in rainwater [6, 11]. The concentrations of Na^+ is within the range of 15.6 to 80.44 mg/l while Cl^- concentrations ranged from 15.76 to 93.64 mg/l. Sulphur (iv) oxide (SO_2) gas emission from automobile exhaust formed Sulphate ion, the (SO_4^{2-}) react with water droplets to form sulphate ions in rainwater. The concentration range in the collected sample is between 0.01 to 5.15 mg/l. The low concentration of sulphate ions is as a result of low emission of automobile exhaust on the study area and the results conform to the standard for safe drinking water [10]. The results of both chloride ions and Sulphate ions are also presented in Figure 3 and 4 respectively. Nitrate ion NO_3^- is obtained from plants, agriculture, animal waste and fertilizers, Nitrate is a major nitrogenous contribution to the chemical composition of precipitation. The HNO_3 gaseous which is obtain from the oxidation of NOx is a water soluble, that is it washed away by rainfall, constituting one of the

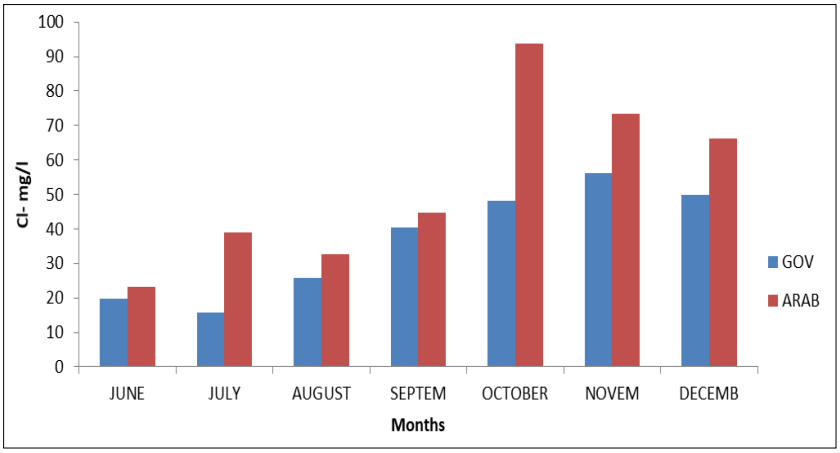

Fig 3: Concentration level of Chloride ions in Rainwater

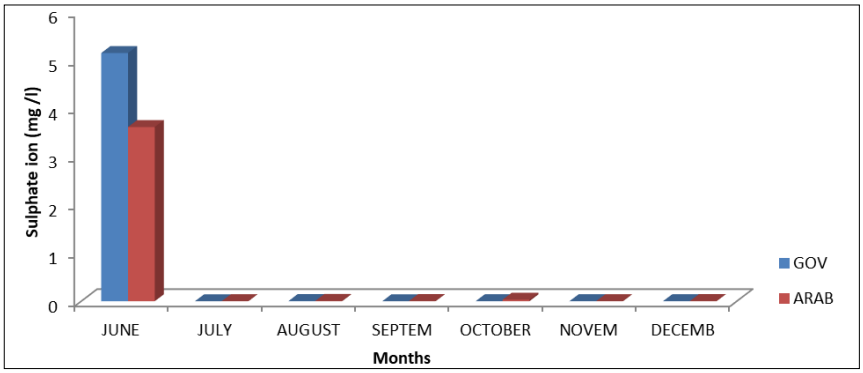

Fig 4: Concentration level of Sulphate ions in Rainwater

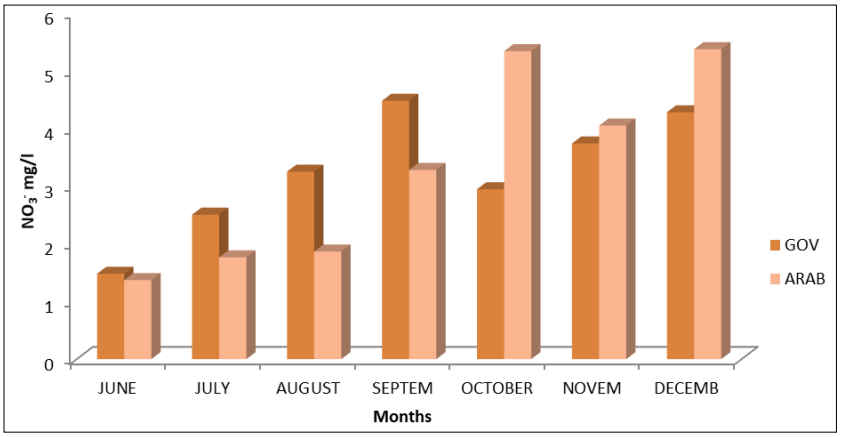

Fig 5: Concentration level of Nitrate ion in rainwater sample

Most essential sources of NO_3^- in rainwater [6, 12]. The concentration of nitrate in rainwater ranged from 1.37 to 5.38 mg/l in the both study area shown Figure 5 below. Maximum concentration was observed in ARAB during the month of October and December this is because during this period the area is more exposed to automobile exhaust and they are found contaminated with more NO_3^- compare to GOVT.

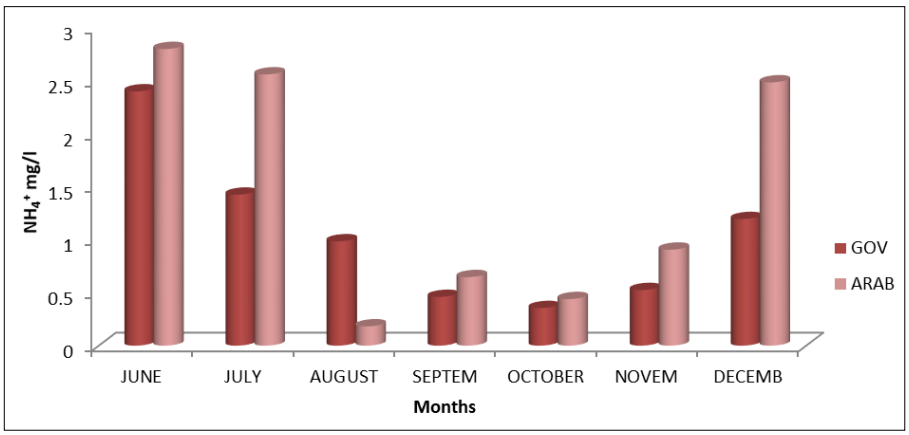

Fig 6: Concentration level of Ammonium ion in rainwater sample

Ammonium is the second contribution to nitrogenous rainwater. In precipitation it results in the condensation of aerosol containing ammonium. The main sources of ammonia are known to be natural or fertilized soils, excrements of human and animals, and wood burnings [6, 13-15]. From Figure 6 and Table 1 above the concentration of ammonium ion is between 0.18 to 2.8 mg/l. The maximum concentration of ammonium ion was found in the month of JUNE, JULY and DECEMBER. This are the months we experience more bush burnings that may have result to the increases in the concentration of ammonium ions in rainwater samples [16, 17].

4. Conclusions

The physical parameters and concentration of the ions of rainwater sample studied conform to the standard for safe drinking water reported by WHO and NIS. Future studies would seek to address the level of trace metals in the rainwater as well as their bacteriological profile.

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