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Physicochemical and Bacteriological Qualities of Indoor Air in Selected Public Primary Schools in Benin City, Edo State

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Abstract

Indoor air quality of schools is critical in any given society for the wellbeing of living components. The aim of this study was to determine the physicochemical and bacteriological qualities of indoor air in selected Public Primary Schools in Benin City, Oredo Local Government Area, Edo State. The indoor air samples were collected from classrooms (Primary 1, 3 and 5) in triplicates from three (3) public primary schools using the Settle Plate Method. The physico-chemical parameters of the indoor air were evaluated using the Portable Hand-held Meterological Instrument respectively. The airborne bacterial isolates were enumerated and identified using the cultural and biochemical methods. The results were analysed using analysis of variance and unpaired Students t-test at 95 % confidence levels. The results revealed that in the wet season, the temperature (^0C) readings ranged from 27.72±0.04 to 34.2±0.97 while in the dry season, it ranged from 28.06±0.14 to 35.38±0.58. The average relative humidity (%) recorded in the wet season, ranged from 63.34±0.13 to 87.42±0.15 and in the dry season it ranged from 57.62±0.09 to 92.56±0.19. The airborne bacterial counts were recorded to range between 3.39±0.49 x 10^2 cfu/m^3 and 12.75±1.61 x 10^2 cfu/m^3. The lowest airborne bacterial counts were recorded in School B while the highest airborne bacterial counts were recorded in School C in the wet and dry season respectively. In all the schools studied, there was no significant difference in the airborne bacteria loads ($p>0.05$) obtained across the dry and wet seasons. Though, some classes recorded high bacterial loads above the permissible limit approved by World Health Organisation (WHO) (5.00 x10^2 cfu/m^3). Based on the cultural and biochemical techniques, five (05) bacterial isolates were identified. They include: Bacillus cereus, Pseudomonas aeruginosa, Staphylococcus spp., Corynebacterium spp. and Enterobacter spp. It is evident that the public school environments assessed are prone to outbreak of diseases arising from poor quality of air and other compromised factors that will influence quality of the wellbeing of the occupants. It is therefore recommended that adequate public health measures are required to mitigate the menace of poor air quality.

1.0. Introduction

Air is the most important component of the environment required to sustain life. Humans can survive for up to a month without food, up to one week without water but deprived of air, they can survive no longer than a couple of minutes [1]. Air is a dynamic system with various sources of particulate matter and bioaerosols. The levels of bioaerosols in the indoor environment depends on the number of the occupants, their activities, building structure, materials, furnishings and the outside air entering the building [2]. Microbial loads are

significantly affected by the presence of human beings in the built environment [3, 4]. The question is how safe is the air in the surrounding environment where one spends much of his/her time?

Indoor environments are fundamental environmental factors capable of impacting health [5]. The quality of indoor air in terms of microbial contamination in a given space at a given time period is said to be determined by the quality of air entering the space, the number of occupants in the space, their physical activities and resultant aerosol generation, human traffic and the degree of ventilation [6]. Microorganisms are present in both indoor and outdoor environments [7], this can result in adverse health effects particularly respiratory problems [8]. Indoor air pollution such as from dampness and mould, chemicals and other biological agents are major causes of morbidity and mortality worldwide. About 1.5 million deaths each year are associated with the indoor combustion of solid fuels, the majority of which occur among women and children in low-income countries [9].

People spend about 80% - 90% of their time in indoor environments by breathing on average 14 m^3 of air per day [10]. Airborne micro-organisms and/or their components have been documented to be responsible for a variety of health problems such as asthma, rhinitis, sick-building syndrome (SBS), infections and many more [11].

Among the indoor microorganisms, some may be pathogenic and could secrete toxic metabolites that can cause allergy and even serious diseases [12]. Human exposure to these airborne microorganisms have been implicated in adverse health effects, infectious diseases, allergic and irritant responses, respiratory problems and hypersensitivity reactions [13].

The increased problem of communicable diseases among school children due to poor hand washing practices and inadequate sanitary conditions remains a concern on the public health agenda in developing countries. The air just like clean portable water is supposed to be human birthright but a contaminated air with pathogenic microbes in the form of aerosolized droplets in the indoor environment is injurious to health.

The school building is part of the structure children needs to pass through as they grow mentally from one stage to another in acquiring academic knowledge. The indoor air quality (IAQ) in school buildings is expected to play a key role in the assessment of the effects of the children personal exposure to air pollution as these children spend at least seven (7) hours or more daily in school [14]. The environmental health status of Nigeria as a developing country is poorly defined in consideration of the fact that, the quality of health is directly related to the quality of the ambient air in indoor and outdoor environment. However, there are no guidelines to assess indoor air quality in Nigeria and no established system to implement the supposed guidelines [15]. The aim of this study was to determine the physicochemical and bacteriological qualities of indoor air in selected Public Primary Schools in Benin City, Oredo Local Government Area, Edo State.

2.0. Methodology

Study Sites

The study was carried out in Benin City, Oredo Local Government Area. Benin City is located on longitude 60^0 20’ 0” North, latitude 05^0 38’ 0” East with a mass of 19,794 km^2. It has a population of about 1, 147, 188 people. Schools assessed had the following coordinates: School A; $N06^0$ 18.609’ $E005^0$ 36.362’, School B; $N06^0$ 19808’ $E005^0$ 36.972’, School C; $N06^0$ 20.739’ $E005^0$ 37.816’.

2.1. Sample collection/procedure

Airborne bacterial samples were collected using the Passive Air Sampling Technique, the Settle Plate Method using 90 mm diameter of Petri dishes. The sampling height was 1 m above the floor. Samples were collected from Classrooms (Primaries 1, 3 and 5) in triplicates from three (3) selected Government owned Primary Schools in Benin City. The three (3) Public Schools were identified as Schools A, B and C. The sampling was carried out once daily and on a monthly basis across wet and dry seasons (May, 2018 - September, 2018 for wet season and October, 2018 - March, 2019 for dry season).

2.2. Determination of the Physico-chemical Characteristics (temperature, relative humidity) of the air

The air temperature and relative humidity were determined using the Portable Hand-held Meterological Instrument (RS humidity/ temperature meter) [16].

2.3. Enumeration, Isolation and Biochemical Identification of Airborne Bacterial Isolates

The airborne bacterial isolates were enumerated and identified using the cultural, morphological and biochemical characteristic features. The colony forming units (cfu) of the airborne bacterial isolates were enumerated and expressed in cfu/m^3 using the formula;

$$cfu/m^3 = \frac{a \times 10000}{p \times t \times 0.2}$$

where;
a: Number of colonies counted in Petri dish
p: Surface area of the 9cm diameter Petri dish (πr^2)
t: Time of exposure (10min)
The mean values from the triplicate plates were estimated and recorded. Pure cultures of distinct colonies were collected and stored in a slant for further studies [5, 17].

2.4. Morphological and Biochemical Characteristics of Bacteria

2.4.1. Gram Stain

Thin smears of the isolates were made on glass slides using a wire loop and were heat-fixed and allowed to cool. The smears were stained with crystal violet stain for a minute before washing off immediately with potable water. Then the smears were covered with Lugol's iodine for 30-60 sec and immediately washed off with water. The smears were rapidly decolorized with acetone or alcohol and washed rapidly with clean water after 5 seconds. Then the smears were stained with slaframine for 60 seconds and immediately washed off. The stained smears were allowed to air-dry after which a few drops of oil immersion were dropped on the smears after which they were viewed under the optical microscope using the 100x objective lens. The Gram-positive organisms were viewed as purple cells while the Gram-negative organisms were viewed as pink or red cells.

2.4.2. Biochemical Tests

These tests were conducted to determine the ability of the bacterial isolates to produce enzymes such as catalase, oxidase, and urease. Other biochemical tests were carried out to determine the ability of the bacteria to either utilize a sugar or substrate sources.

2.4.3. Catalase (Hydrogen peroxide; H_2O_2) Test

The biochemical test was carried out to assess and detect if the enzyme catalase is present. Catalase is an enzyme that catalyzes the release of oxygen from hydrogen peroxide with a resultant effervescence. Catalase catalyzes the breakdown of toxic H_2O_2 (hydrogen

peroxide) into water and oxygen, which are harmless. The enzyme is produced or expressed by all aerobic organisms and thus it is a useful test in differentiating members of the aerobic and anaerobic organisms.

2.4.3. Procedural Methodology: a drop of H_2O_2 (3 %) is placed on a grease free slide to which a loopful of the bacteria isolate is applied. Positive catalase activity was shown by effervescence, while no effervescence indicates absence of the enzyme.

2.4.4. Oxidase Test

The biochemical test is basically carried out to identify the presence of the artificial electron acceptor (cytochrome-c-oxidase), which is able to reduce oxygen. It is used to detect the presence of the enzyme in bacteria. That is, if certain oxidases which are required for the transportation of electrons between tetramethyl-p-phenylene-diamine (the redox dye) and electron donors in the bacteria are present or not.

2.5. Procedure: A whatman filter paper was soaked with a solution of 1% tetramethlyphenylene diamine hydrochloride. A 24 hours culture of the test isolate(s) was smeared onto the impregnated filter paper. The presence of a purple colour, indicated a positive result.

2.6. Test for Urea Hydrolysis (Urease Test)

This was performed to show the capability of some bacteria to form an alkaline product (ammonia) via splitting urea under the influence or action of the enzyme urease.

2.6.1. Procedure: Urea was added to urease agar base before it was inoculated with the test organism in a slant. At optimum temperature incubation was done (37 ^{0}C) for 24-48 hrs. The development of an intense pink/red color is indicative of a positive results while negative results showed no colour."

2.7. Indole Formation Test

This biochemical test was performed to evaluate the capability of bacteria to produce indole via the hydrolysis of tryptophan. The spot indole test was used in this study to detect rapid indole producing organisms. This test is used to detect the presence of tryptophanase, an enzyme which catalyze the breakdown of tryptophan to release indole on reaction with cinnamaldehyde to produce a blue-green compound. When the enzyme is absent, there would be no colour production (indole negative).

2.7.1. Procedure: saturate the filter paper with 1% paradimethylaminocinnamaldehyde reagent. Use a loop to remove a colony of the culture to be tested from the agar surface and robbed on the surface of the filter paper already saturated with the reagent. Positive result is confirmed when a blue colour develop within 30 seconds. Most indole-producing organisms turn blue within 30 seconds to one minute. The development of a slightly pink coloration or none at all is indicative of a negative result.

2.8. Citrate Utilization Test (Simon Citrate Agar (SCA) Slant)

SCA slants were used for this biochemical testing procedure. It is usually performed to evaluate the capability of the bacterium to utilize citrate as its sole carbon source. The biochemical medium contains sodium citrate (sole carbon source), bromothymol blue (indicator) as well as ammonium dihydrogen phosphate (nitrogen source).

2.8.1. Procedure: prepare the medium as a slant using a test tube and culture the bacteria isolates to be tested and allowed to stand for 24 hours in an incubator. Development of a blue colour indicates a positive reaction to citrate while no colour change or if the green colour of the medium is retained, indicates a negative reaction.

2.9. Statistical Analysis

SPSS Statistics 21.0 software was used to evaluate data. Analysis of variance and unpaired students *t* test was used to statistically analyse the differences in physicochemical parameters of indoor air samples in Classrooms as well as seasonal variations of indoor air [18].

3.0. Results

The results of the comparative analysis of temperature and humidity from selected Primary Schools in the wet and dry periods are shown in Table 1. It was observed that there was no statistical difference ($p>0.05$) in temperature between wet and dry period in the period of study. More so, there was also no statistical difference ($p>0.05$) between wet and dry periods in the period of study.

The results of the airborne bacterial population in the wet and dry seasons of the schools studied are presented in Fig.1 and 2. Fig. 1 presents the results of the airborne bacterial population, the mean airborne bacterial population in the wet season ranged from $1.81\pm0.59 \times 10^2$ cfu/m^3 to $6.31\pm1.43 \times 10^2$ cfu/m^3 in School A, $2.36\pm0.83 \times 10^2$ cfu/m^3 to $6.39\pm0.76 \times 10^2$ cfu/m^3 in School B and $4.40\pm1.02 \times 10^2$ cfu/m^3 to $17.37\pm0.98 \times 10^2$ cfu/m^3. The highest airborne bacterial population was recorded in School C ($17.37\pm0.98 \times 10^2$ cfu/m^3) in the month of July, 2018, while the lowest airborne bacterial population was recorded in School A ($1.81\pm0.59 \times 10^2$ cfu/m^3) in the month of May, 2018.

The mean airborne bacterial population in the dry season ranged from $1.70\pm0.49 \times 10^2$ cfu/m^3 to $10.74\pm0.99 \times 10^2$ cfu/m^3 in School A, $2.02\pm0.32 \times 10^2$ cfu/m^3 to $6.86\pm0.57 \times 10^2$ cfu/m^3 in School B and $2.69\pm1.07 \times 10^2$ cfu/m^3 to $19.69\pm2.01 \times 10^2$ cfu/m^3 in School C (Fig. 2). The highest airborne bacterial population was recorded in School C and lowest airborne bacterial population was recorded in School A .

The comparative bacterial loads during the wet and dry periods are shown in Table 4. The lowest bacterial counts were recorded in School B in the wet period ($3.39\pm0.49 \times 10^2$ cfu/m^3) while the highest bacterial count was obtained in school C in dry period ($12.75\pm1.61 \times 10^2$ cfu/m^3). In all primary schools studied, there was no significant difference in the bacteria loads ($p>0.05$) obtained across the dry and wet period of sampling.

Based on the cultural, morphological and biochemical tests, the following airborne bacterial isolates were identified; *Bacillus cereus, Pseudomonas aeruginosa*., *Staphylococcus aureus*, *Corynebacterium* spp., *Enterobacter* spp.

Table 1. Physicochemical parameters of indoor air quality of primary schools (classrooms) in raining period (May –September 2018)

		SCHOOL A		SCHOOL B		SCHOOL C	
Month	Class	Temp. (^{O}C)	Humidity (%)	Temp. (^{O}C)	Humidity (%)	Temp. (^{O}C)	Humidity (%)
MAY	Primary 1	34.60±0.00^{a}	63.34±0.13^{a}	32.30±0.00^{a}	68.40±0.29^{a}	34.92±0.97^{a}	66.92±0.15^{a}
	Primary 3	32.96±0.24^{b}	71.08±0.31^{b}	32.78±0.02^{a}	68.24±0.06^{a}	33.00±0.000^{b}	70.16±0.07^{b}
	Primary 5	33.20±0.00^{c}	67.64±0.18^{c}	32.60±0.40^{a}	68.34±0.08^{a}	33.02±0.02^{b}	66.22±0.13^{c}
JUNE	Primary 1	29.58±0.04^{a}	75.58±0.07^{a}	28.60±0.05^{a}	75.64±0.02^{a}	28.94±0.05^{a}	81.74±0.09^{a}
	Primary 3	30.68±0.02^{b}	74.42±0.10^{b}	29.00±0.03^{b}	77.64±0.42^{b}	29.90±0.00^{b}	77.70±0.15^{b}
	Primary 5	30.60±0.00^{c}	77.24±0.13^{c}	29.98±0.02^{c}	74.24±0.25^{c}	29.20±0.03^{c}	73.94±0.05^{c}
JULY	Primary 1	31.28±0.05	72.52±0.15^{a}	29.38±0.02^{a}	77.48±0.52^{a}	27.72±0.04^{a}	83.94±0.13^{a}
	Primary 3	30.88±0.02	74.26±0.20^{b}	29.72±0.02^{b}	75.08±0.09^{b}	29.30±0.03^{b}	80.62±0.24^{b}
	Primary 5	30.02±0.02	72.42±0.53^{a}	31.08±0.04^{c}	72.38±0.15^{c}	29.84±0.03^{c}	73.36±0.03^{c}
SEPTEMBER	Primary 1	31.94±0.02	73.36±0.61^{a}	33.96±0.02^{a}	67.84±0.22^{a}	27.88±0.07^{a}	87.42±0.15^{a}
	Primary 3	32.00±0.00	71.76±0.22^{b}	33.30±00^{b}	70.18±0.13^{b}	29.42±0.04^{b}	86.28±0.21^{b}
	Primary 5	31.88±0.02	72.30±0.23^{ab}	33.02±0.02^{c}	71.36±0.36^{c}	30.30±0.00^{c}	75.54±0.13^{c}

Key: same alphabets across columns indicate no significant difference ($p>0.05$)

Table 2. Physicochemical parameters of indoor air quality of primary schools (classrooms) in Dry period (October 2018 to March 2019)

		SCHOOL A		SCHOOL B		SCHOOL C	
Month	Class	Temp. (^{O}C)	Humidity (%)	Temp. (^{O}C)	Humidity (%)	Temp. (^{O}C)	Humidity (%)
OCTOBER	Primary 1	28.06±0.14^{a}	92.56±0.19^{a}	30.18±0.02^{a}	79.48±0.20^{a}	28.06±0.14^{a}	92.56±0.19^{a}
	Primary 3	31.06±0.25^{b}	79.34±0.42^{b}	30.48±0.02^{b}	77.60±0.05^{b}	30.06±0.03^{b}	83.06±0.09^{b}
	Primary 5	31.76±0.25^{c}	79.08±0.18^{b}	30.62±0.84^{c}	78.64±0.03^{c}	30.20±0.00^{b}	76.48±0.02^{c}
NOVEMBER	Primary 1	35.38±0.58^{a}	70.06±0.38^{a}	30.98±0.02^{a}	82.58±0.09^{a}	30.98±0.02^{a}	81.90±0.31^{a}
	Primary 3	34.60±0.45^{b}	71.40±0.12^{b}	31.34±0.03^{b}	80.72±0.15^{b}	30.92±0.05^{a}	82.16±0.36^{a}
	Primary 5	34.30±0.00^{c}	68.52±0.12^{c}	31.66±0.03^{c}	79.60±0.31^{c}	31.12±0.02^{b}	78.10±0.06^{b}
JANUARY	Primary 1	31.52±0.04^{a}	71.32±0.08^{a}	32.40±0.00^{a}	70.36±0.09^{a}	30.18±0.05^{a}	72.40±1.63^{a}
	Primary 3	31.68±0.07^{b}	72.96±0.16^{b}	32.74±0.11^{b}	70.60±0.20^{a}	30.641±0.05^{b}	77.76±1.11^{b}
	Primary 5	31.76±0.25^{b}	72.90±0.06^{b}	33.18±0.02^{c}	65.96±0.05^{b}	31.48±0.02^{c}	72.14±0.14^{a}
FEBRUARY	Primary 1	31.58±0.02^{a}	62.36±0.09^{a}	32.66±0.25^{a}	57.62±0.09^{a}	30.80±0.06^{ab}	61.18±0.35^{a}
	Primary 3	32.00±0.00^{b}	62.12±0.06^{a}	32.40±0.00^{b}	61.18±0.12^{b}	30.70±0.00^{a}	62.86±0.24^{a}
	Primary 5	32.00±0.00^{b}	62.32±0.11^{a}	32.54±0.25^{c}	60.80±0.26^{b}	30.88±0.02^{b}	66.50±1.31^{b}
MARCH	Primary 1	31.86±0.03^{a}	74.52±0.05^{a}	32.66±0.25^{a}	73.28±0.04^{a}	30.5±0.00^{a}	77.08±0.09^{a}
	Primary 3	32.40±0.03^{b}	76.58±0.16^{b}	32.64±0.25^{a}	75.96±0.76^{b}	30.76±0.51^{b}	79.60±0.37^{b}
	Primary 5	32.10±0.05^{c}	75.84±0.13^{c}	33.02±0.20^{b}	72.20±0.06^{a}	30.14±0.00^{c}	74.58±0.21^{c}

Key: same alphabets across columns indicate no significant difference ($p>0.05$)

Table 3. Comparative analysis of temperature and relative humidity in the Primary Schools in the wet and dry periods
Wet period = May, 2018, June, 2018, July, 2018 and Sept., 2018;
Dry period =Oct., 2018 and Nov., 2018, Jan., 2019 - Mar., 20

		Temperature			Relative Humidity		
Primary Schools	Classes	Wet period	Dry period	*p value*	Wet period	Dry period	*p value*
SCHOOL A	Pry 1	31.85±1.04	31.68±1.16	0.918	71.20±2.69	68.16±1.83	0.798
	Pry 3	31.63±0.53	32.34±0.60	0.415	72.88±0.86	72.48±0.94	0.910
	Pry 5	31.42±0.72	32.38±0.48	0.285	72.41±1.96	71.73±2.93	0.862
SCHOOL B	Pry 1	31.06±1.25	31.77±0.51	0.582	72.34±2.47	72.66±4.34	0.954
	Pry 3	31.20±1.08	31.92±0.44	0.522	72.78±2.17	73.21±3.43	0.924
	Pry 5	31.85±0.07	32.20±0.48	0.672	70.58±0.87	71.44±3.62	0.843
	Pry 1	29.87±1.71	30.17±0.52	0.886	79.25±4.15	77.02±5.18	0.757
SCHOOL C	Pry 3	30.40±0.88	30.49±0.17	0.911	78.69±3.36	77.08±3.68	0.763
	Pry 5	30.58±0.84	30.76±0.26	0.824	72.25±2.70	73.56±2.03	0.668

Table 4: Comparative analysis of the bacterial load during the wet and dry periods

Primary Schools	Class	Wet period	Dry period	*p value*
SCHOOL A	Pry 1	4.44±1.04	6.20±1.48	0.362
	Pry 3	3.96±0.86	5.25±1.38	0.453
	Pry 5	3.91±0.81	4.42±1.29	0.753
SCHOOL B	Pry 1	4.60±0.72	4.18±0.14	0.656
	Pry 3	5.14±0.82	4.18±0.73	0.414
	Pry 5	3.39±0.49	3.88±0.63	0.559
	Pry 1	10.42±2.61	12.75±1.61	0.481
SCHOOL C	Pry 3	6.72±0.81	11.60±2.91	0.172
	Pry 5	5.48±0.52	6.84±1.62	0.463

KEY: Wet period = May, 2018, June, 2018, July, 2018 and Sept., 2018;
Dry period = Oct., 2018, Nov., 2018, Jan., 2019 - Mar.,2019

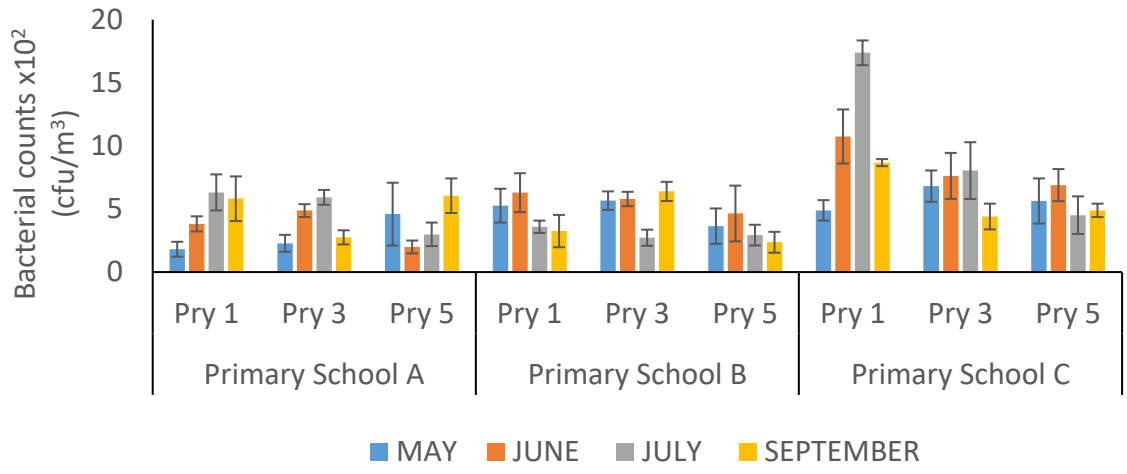

Figure 1: Mean airborne bacterial counts (cfu/m^3) in Primary Schools A, B and C in the wet period (May, 2018, June, 2018, July, 2018 and September, 2018)

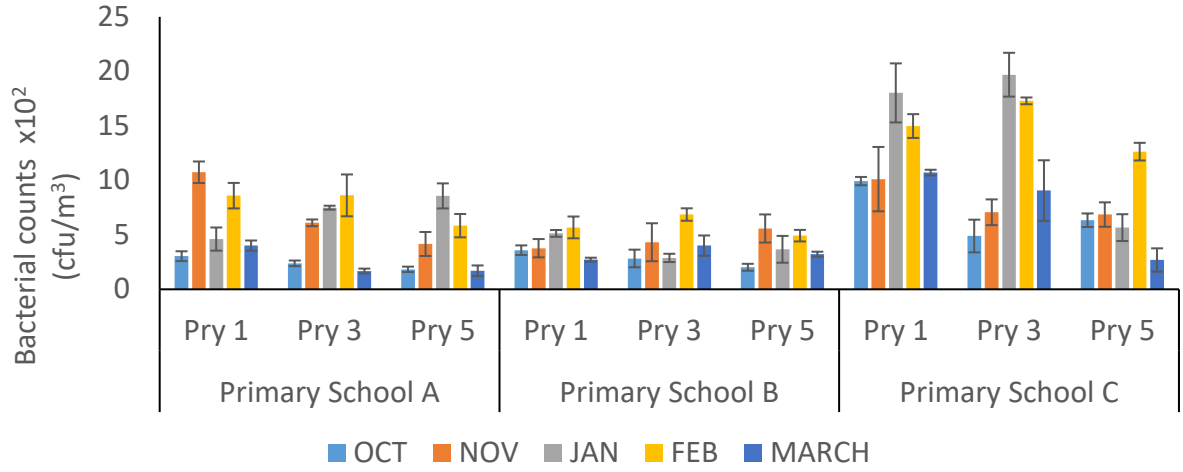

Figure 2: Mean airborne bacterial counts (cfu/m^3) in Primary Schools A, B and C in the dry period (Oct., 2018, Nov., 2018, Jan., 2019, Feb., 2019 and Mar., 2019)

3.1. Discussion

The results of the meteorological parameters during the wet season revealed temperature (^{0}C), to range from 27.72±0.04 to 34.2±0.97. The lowest and highest values were recorded in School C. In the dry season, the temperature (^{0}C) ranged from 28.06±0.14 to 35.38±0.58 and the lowest and highest temperature were recorded in School A. The relative humidity (%) ranged from 63.34±0.13 to 87.42±0.15 in the wet season with the lowest and highest values were recorded in Schools A and C respectively. The results of the relative humidity in the dry season ranged from 57.62±0.09 to 92.56±0.19. The lowest value was observed in school B while the highest value was observed in School C. it was observed all through the periods of sampling that temperature and relative humidity were however related as it was found that an increase in one lead to a decrease in the other. This finding was in agreement with the reports of Yassin [19], who reported that the relative humidity and temperature are closely associated and with special reference to microbial growth, lower temperature correlates with higher humidity which in turn favours microbial growth. Similarly, the same trend for temperature and relative was observed in the report of Bragoszewska [20] who studied the influence of meteorological factors on the level and characteristics of culturable bacteria in the air in Gliwice, Upper Silesia, Poland. It was reported that an increase in temperature always correlated with a decrease in relative humidity and vice versa.

The microbiological components of these parameters with their corresponding effect on human health has also been profiled in literatures. Several authors have reported the effect of meteorological factors on the growth and survivability of bacteria in the environment. Meteorological conditions, including temperature, wind velocity and relative humidity, are among the most important factors influencing the concentrations of outdoor bacteria as well as their indoor counterparts including fungi species [21, 22, 23, 24, 25]. This is possibly very true to its core because of the role played by temperature and relative humidity on the growth and proliferation of bacteria and other microorganisms. Moreso, high water activity is typically favourable for bacterial growth because the bacteria can absorb this water from their living substrates for metabolism. In addition, high relative humidity may result in the clumping of the cells, which possibly increases odds of cell survival [26]. The microbial activity of bioaerosols will be inhibited if the RH is too low because a dry environment depresses the metabolism and

physiological activities of microorganisms [20]. The relative humidity and temperature of the selected schools in the seasons evaluated were found to favor the growth of bacteria in the indoor air of selected school's classrooms. The results obtained in this study is in line with several reports, which confirms that relative humidity positively correlates with bacterial aerosol concentrations; however, this relationship was only statistically significant in winter (0.476; p\ 0.05) according to Bragoszewska [20]. More so, Yassin [19] reported a similar opinion about the role played by relative humidity and temperature on the corresponding bacteria or microbial population in the indoor and outdoor air environment. The seasonality of the concentration of bacteria in the indoor air environment as evaluated in this study was also found to be in concert with several reports in literatures. Technically speaking, between dry and wet seasons of sampling, the lowest bacterial count was observed in school B in the Wet Season ($3.39\pm0.49 \times 10^2$ cfu/m^3) and the highest count was obtained in school C during the dry season ($12.75\pm1.61 \times 10^2$ cfu/m^3). In all schools assessed, there was no significant difference in the bacteria loads ($p>0.05$) obtained across the dry and wet seasons. Following the aforementioned results of the bacterial burden, it can be inferred that the classrooms had intermediate degree of contamination (between 100 – 500 cfu/m^3) to high bacterial degree of contamination (500 – 2000 cfu/m^3) as delineated by European Commission 1993 and Commission of the European Communities (2008). The values obtained in this study from the Primary Schools is in concert with several reports in literatures on the bacteriological indoor air quality. Shahida [27] monitored the indoor bacterial and fungi air quality at different Nurseries and Day Care Centres and reported intermediate degree of contamination as counts were above 500 cfu/m^3, within the range of 730 - 3330 cfu/m^3. Similar results were also obtained from the study carried out by Fang [28], who evaluated the characteristics and concentration distribution of culturable bacteria in residential homes in China. It was reported that, few homes had very low level of bacterial contamination (< 50 cfu/m^3), majority of the homes in the study had intermediate contamination level which were similar to the report obtained in this study. More so, Brągoszewska [29] evaluated the microbiological indoor air quality of office building and made similar observations which were in agreement with the results obtained in this study. They reported that bacterial quality of office buildings in Upper Silesia, Poland where within 100 cfu/m^3 to 1000 cfu/m^3, this can be interpreted as having low to intermediate level of bacterial contamination. Furthermore, Ekhaise [30] also made similar observation in their study, in the hospital environment in Benin City and reported that that most indoor environment assessed were found to have intermediate level of contamination. Similarly, the results obtained by Kunwar [31] also supported the findings in this study as the bacteriological assessment of indoor air quality of different hospitals in Kathmandu District in Nepal, revealed some indoor air to have intermediate to very high level of bacterial contamination. However, the results by Al-Mijalli [32] about how the bacterial counts was more in classrooms with higher student population were in perfect consonance with the results obtained in this study as higher bacterial counts were reported in School C which had more pupils in the classrooms than the other Schools assessed.

4.0. Conclusion

The indoor air environment of classrooms is sacrosanct to the wellbeing of the pupils and as such care should be taken to ensure that clean and bright air be made available via proper ventilation measures in the public schools. Monitoring of the indoor air quality of primary schools in Benin City is of utmost importance as it has been found that the health of the child will be greatly influenced by the quality of the indoor air which is being inhaled.

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