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Comparative Studies of Vegetative Growth of Barbula indica, From Polluted and Unpolluted Sites at the Obafemi Awolowo University, Ile-Ife, Nigeria

[1]Tolulope Victor BORISADE, [2]Amos Morakinyo MAKINDE

[1, 2] Department of Botany, Obafemi Awolowo University, Ile-Ife BC220005, Nigeria

Abstract: **The investigation of vegetative growth of polluted samples of *Barbula indica* (hook.) Spreng were carried out along road 2, near the computer building along staff quarters on unplastered wall where exhaust fumes from vehicles is rampant and the unpolluted samples were collected in Biological Garden of Obafemi Awolowo University, Ile-Ife, Nigeria. This was with a view to comparing polluted and unpolluted samples in order to monitor their vegetative growth. The results from this study showed that *B. indica* have number of shoots and average number of leaves increased steadily for unpolluted samples in contrast to the polluted ones which decreased throughout the experimental periods. The average heights for both samples (polluted and unpolluted) investigated during the experimental period seldom exceeded 1.0 cm. There were significant differences at ($p \leq 0.05$) for the average number of leaves, heights and shoots with the unpolluted samples significantly higher than polluted samples of *B. indica*. It can be concluded that more shoots emerged from the base of plant and that pollution affected the vegetative growth of the plant.**

Keywords: **vegetative growth, innovations, polluted, unpolluted, moisture.**

1. INTRODUCTION

Bryophyta is one of the divisions of the plant kingdom,among the lower plants .The name bryophyta was frist introduced by Hackel (1886). Bryophyte were classified under the primitive plants known as ‘Cryptogam or Flowerless plants’.They are rich green plants that are seen painting the trees and making them unique . They are non- vascular land plants having tissues and enclosed reproductive system; neither flower nor produce seeds but reproduce through spores (Chopra and Kumra 1988).

Propagation method are either sexual or asexual or both. More copious and varied means of vegetative reproduction exhibit in mosses than any other sections of the plant kingdom (Sach and Vines 1982). Unlike seed plants, all bryophytes are capable of significant clonal expansion through gametophytic growth, fragmentation and in many cases production of specialized asexual propagules (Newton and Misher 1994). Leaf regeneration in bryophytes has not been widely studied. Several studies have confirmed that most mosses and liverwort are capable of efficient regeneration from leaves (Kumar *et al.* 2000). Akinfewa and Odu (1991), showed a great multiciplicity of forms of vegetative propagules from which new generation of adult plants are often established on various substrates.

Several groups of organisms have been used as bio-indicators of atmospheric pollution. The most commonly used are mosses (Pearson *et al*. 2000), which is well known for the monitoring of heavy metal atmospheric deposition in terrestrial ecosystem (Rulings 2002). Mosses are deprived of cuticle and epidermis and their leaves are therefore highly permeable to water and solutes, such ions of trace elements.

In additions to lack of roots and vascular system, make mosses well studies of atmospheric deposition. Indeed, mineral salts and ions presents in mosses come from atmospheric precipitation and dry deposition through simple processes of ion exchange, whereas the uptake from substratum is negligible (Steinnes 1993). The use of mosses as bio-indicator can be attributed to their tolerance to heavy metals (Kakulu 1993) and ability to accumulate toxic elements (Kovacs *et al.* 1993). Atmospheric pollution has important consequences on the environment, economy, human health and the society. The types of atmospheric pollutants and the pollution levels depends on many factors, such as emission sources, physical conditions and meteorological parameters (Gilbert *et al*. 2007)

There is little investigation on the vegetative growth of bryophytes especially in Nigeria. The study therefore, compared the vegetative growth in polluted and unpolluted samples of *Barbula indica* within its natural populations in Ile –Ife, Nigeria.

2. MATERIALS AND METHODS

Study Area:

Polluted samples of *Barbula indica* was collected on unplastered wall near computer building, on the way to staff quarters with coordinates; latitude 07°32.612ˡ N and longitude 40°31.632ˡE (Pollutions apparently through gases from exhaust pipes of vehicles along road 2). Unpolluted samples were collected from the Biological Garden of Obafemi Awolowo University, Ile-Ife, Nigeria with coordinate; Latitude 7°31.405' and Longitude 4°31.412'. The elevation of the areas ranges from 289 m to 301 m above sea level. The vegetation of Ile-Ife is lowland rainforest agricultural mosaic with small patches of derived savanna on inselberg (White 1983). There are two prominent seasons in Ife area, the rainy season (March - November) and the dry season (November-March). The most recent climatic survey conducted in 2013 by the Atmospheric Physics Research Group, Department of Physics and Engineering Physics, Obafemi Awolowo University, Ile-Ife, showed that the annual rainfall averaged 1302 mm per year, with relative humidity of 82.80%, average temperature of 25.5 °C, solar radiation of 164.30 Wm^{-2} and average wind speed of 2.06 km per hour.

Onochie (1979) reported that Ile-Ife area lies in a dry deciduous forest zone. White (1983) also describes the vegetation as Guineo-Congolian drier type. The area is underlain by rocks of the Basement Complex, which are of Precambrian age (Wilson 1922). The basement complex consists of heterogeneous group of rocks (gneisses, schists, granite and minor rocks types such as pegamites).

The soil has been classified as Lixisols (FAO/UNESCO 1974) and Ultisols (USDA 1975). The soils which are usually acid contain less than 10% clay which is mainly Kaolinite and hence are characterized by low cation exchange capacity and low water holding capacity (Ayodele 1986).

Moss sampling:

A Quadrat-like device of the size 2.0 cm × 2.0 cm was constructed and used in collecting the samples from the sites. The quadrat was placed randomly and the plants that were within the 4.0 cm^2 areas were collected fortnightly using envelopes. The plant samples collected were brought to the laboratory and were washed to remove soil and dust particles. The samples (polluted and unpolluted) were observed using dissecting microscope in which the number of shoots per 4.0 cm^2 was counted, Innovations from sides of the shoots and the numbers of leaves were noted.

The shoots height was measured using metric ruler. The surface temperature of the plant samples collected was recorded using mercury-in-glass thermometer. Out of the samples stored in each envelope, ten randomly selected shoots were weighed in their fresh state. The samples stored in envelopes were dried to constant weight in an oven for one hour at 70°C. Ten shoots from each envelope were weighed using weighing balance (Scout ^{Tm} pro version 2000) to obtain the dry weight. Moisture content was then determined using formula: Mc (%)= $\frac{Fw-Dw}{Fw} \times 100$ (where Mc = moisture content, Fw = fresh weight and Dw = dry weight). The experiment lasted for a period of three months and three weeks.

Statistical Analysis:

The average height of the ten randomly selected plants found in 4.0 cm^2 area, average number of leaves of ten randomly selected plants in 4.0cm^2 area, Number of shoots (Population) in 4.0 cm^2 area, Innovations, Fresh weight, Dry weight and Moisture contents for ten randomly selected plants, were subjected to student t- paired test to compare between the polluted and unpolluted samples of the plants.

3. RESULTS

Results from the qualitative studies of the vegetative growth of the plant (*Barbula indica)* of the randomly selected plants are shown in figure 1; There was steady increase in the number of shoots per 4.0 cm² area (Population) of the unpolluted samples. The increase was noticeable in the 3rd, 11th and 13th week, with the 1st week having the lowest population whilst the 15th week exhibited the highest population. In contrast to the polluted samples where there was a steady decrease in the population from the 1st to the 15th week.

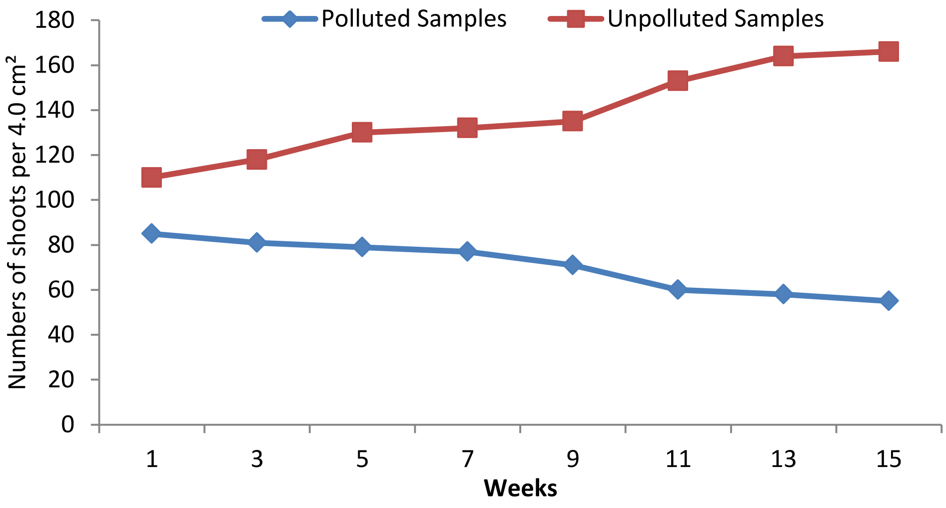


Fig.1: Numbers of shoots (Populations) of *B. indica* in 4.0 cm² quadrats for each week.

*Blue colour represent polluted samples while red colour represents polluted samples.

There was significant difference at ($p \leq 0.05$) with the unpolluted samples exhibiting the greater mean. Figure 2, showed the details of the average number of leaves. The average number of leaves increased uniformly from the 1st week up to the 7th week for the unpolluted samples, which decreased slightly in the 9th week, and there were fluctuations up to the 15th week. There was a percentage increase in the average number of leaves for the polluted samples by 12% in the 1st to 3rd week, decrease by 16% in the 3rd to 5th week. It was noted that average number of leaves had a range of 10 to 13 from the 7th to 15th week for the polluted samples, t-test analysis for average number of leaves (n=10) carried during the experimental periods shows that there were significant difference at ($P \leq 0.05$) with the unpolluted samples exhibiting the greater mean.

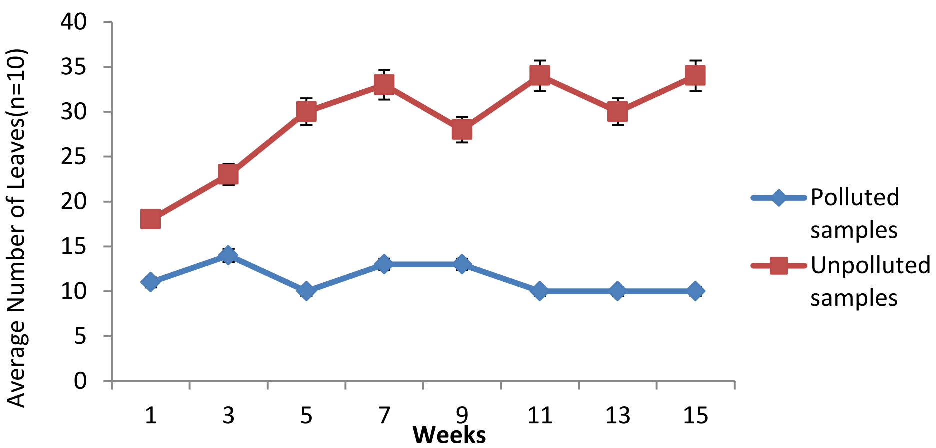


Fig.2: Average number of leaves of ten randomly selected mosses.

*Blue colour represent polluted samples while red colour represents polluted samples.

Figure 3 showed the details of the average height of the shoot for 15 weeks. There was a gradual increase in the average height of the shoots for the unpolluted samples except in the 11^{th} week where there was decrease in the average height of the shoots by 19%, In contrast to the polluted samples [in which was an increase in the average height (1^{st} to 3^{rd} week)]. There was a percentage decrease in the 3^{rd} to 5^{th} week by 6%, in the 5^{th} to 7^{th} week by 7.4% and 7^{th} to 9^{th} week by 4.1%, it increased in the 11^{th} to 13^{th} week and decreased in the 15^{th} week, t-test analysis for average heights of the shoots (n=10) carried out during the experimental periods shows that there was significant difference at ($P \leq 0.05$) with the unpolluted samples significantly higher than the polluted samples.

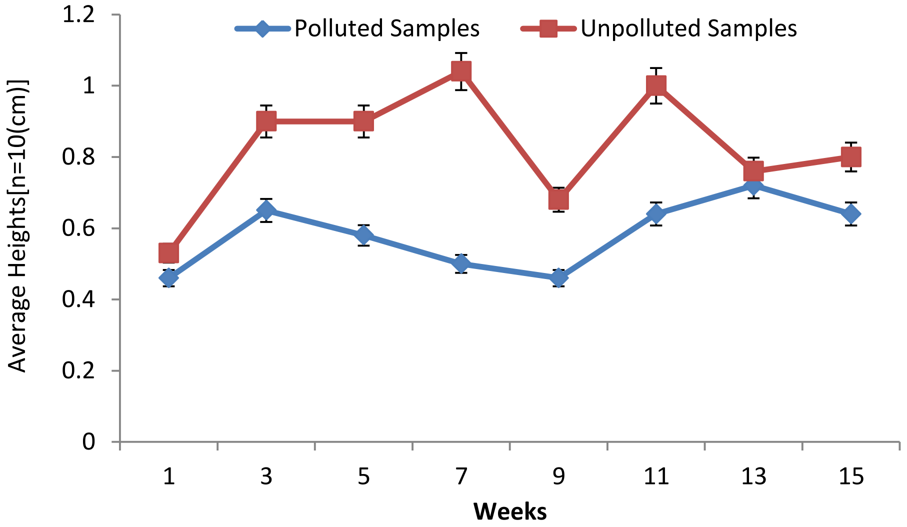


Fig.3: Average heights of the shoots for selected mosses

*Blue colour represent polluted samples while red colour represents polluted samples.

Figure 4 showed that the surface temperature for both samples (Polluted and unpolluted) were slightly close. For the unpolluted samples, the highest temperature was observed in the 15^{th} week (32°C) and lowest in the 11^{th} week (27°C). For the polluted samples, the highest temperature was observed in the 7^{th} week (32°C) and lowest at the 5^{th} and 11^{th} week (27.2°C), t-test analysis for surface temperatures carried out during experimental periods reveals that there were no significant differences at ($P \leq 0.05$).

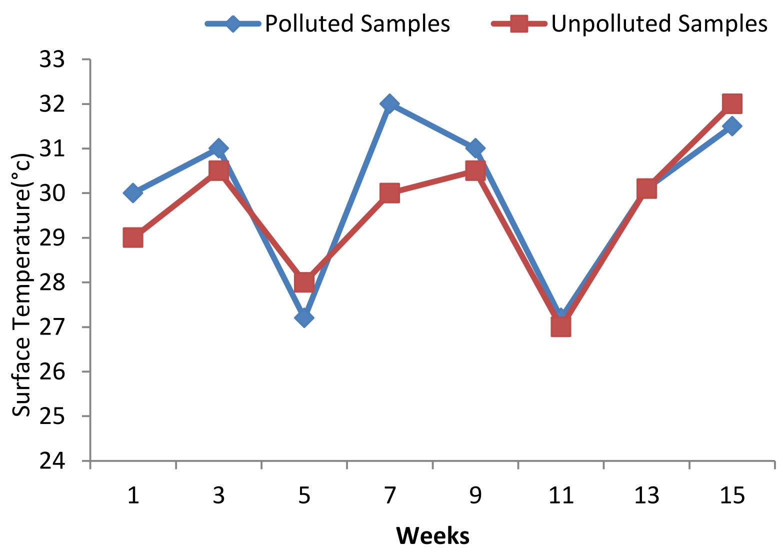
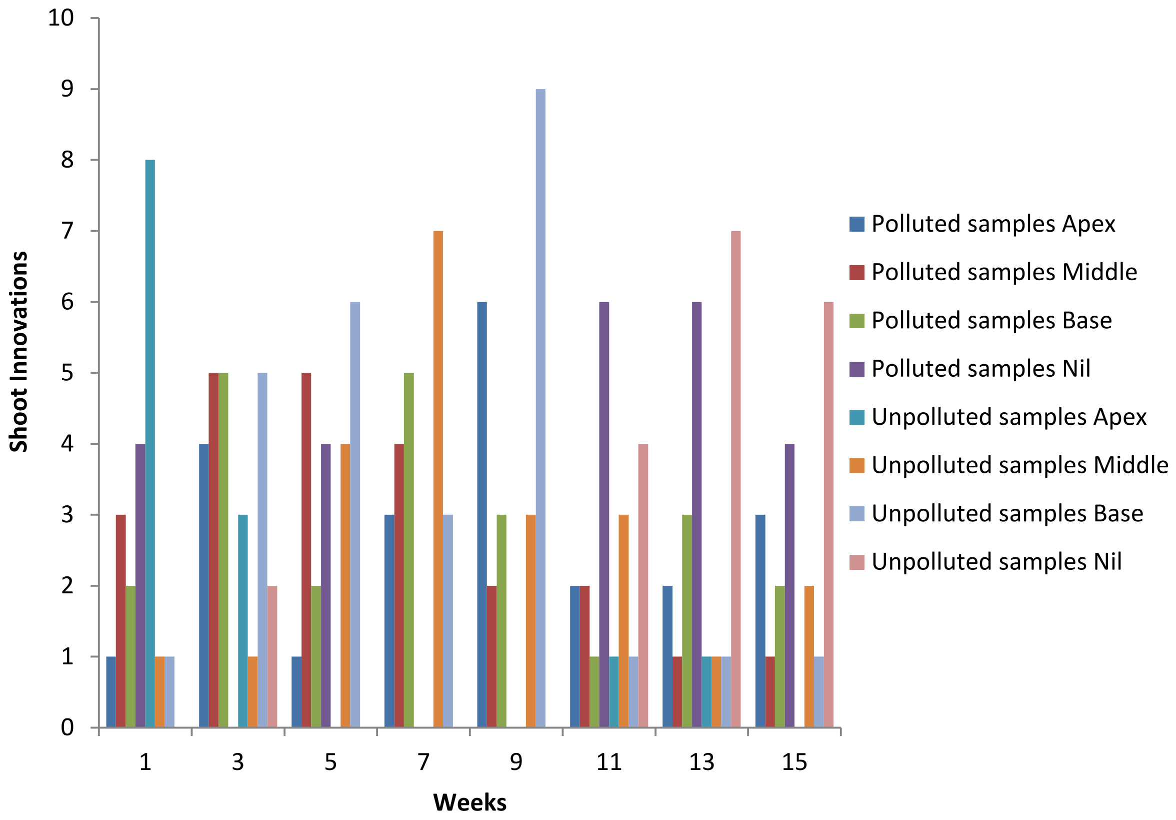


Fig.4: Shows fortnight variations in surface temperature of B. indica on the field

*Blue colour represent polluted samples while red colour represents polluted samples.

Figure 5, showed the details of innovations of the plants. For the unpolluted samples, innovations from sides of the shoots revealed that the apex had the highest frequency of eight in the 1st week and no frequency in the 5th, 7th, 9th and 15th week. However, innovations from the sides of the shoots revealed the middle, having the highest frequency of seven in the 7th week, and the lowest frequency of one in the 1st, 3rd, and 13th week. Innovations from sides of the shoots shows that the base has the highest frequency of nine in the 9th week and lowest frequency of one in the 1st , 11th, 13th , and 15th week. The 13th week exhibited the highest frequency of seven in which there were no innovations (Nil), and in the 1st, 5th, 7th and 9th week had the lowest frequency of zero. For the polluted samples, innovations from the sides of the shoots revealed that the apex had the highest frequency of six in the 9th week, and the lowest frequency of one in the 1st and 5th week. Innovations from sides of the shoots shows that the middle had the highest frequency of five in the 3rd and 5th week and the lowest frequency of one in the 13th and 15th week. Innovations from the sides of the shoots revealed that the base had the highest frequency of five in the 5th week and lowest frequency of one in the 11th week. The 11th and 13th week exhibited the highest frequency of six in which there were no innovations (Nil) and the 3rd, 7th and 9th week had the lowest frequency of zero, t-test analysis for shoot innovation carried out during experimental periods reveals that there were no significant differences at ($P \leq 0.05$).



*Deep blue, deep red, green and Purple represents innovation in polluted samples at the apex, middle, base and no innovation for polluted samples respectively. Light blue, yellow light-dark blue and pink represents innovation at the apex, middle, base and no innovation in unpolluted samples respectively.

Fig.5: Innovations from sides of the shoot

Figure 6 showed details of the dry weights of the polluted and unpolluted samples of the plant. The dry weight of the shoots (n=10) for the unpolluted samples was highest in the 13th week (17.0 mg) and lowest in the 1st and 9th week (2.0 mg). The dry weight was highest in the 1st week (6.0 mg) and lowest at the 5th week (1.0 mg) for the polluted samples, t-test analysis for the dry weights of the shoots reveals that there were no significant differences at ($P \leq 0.05$).

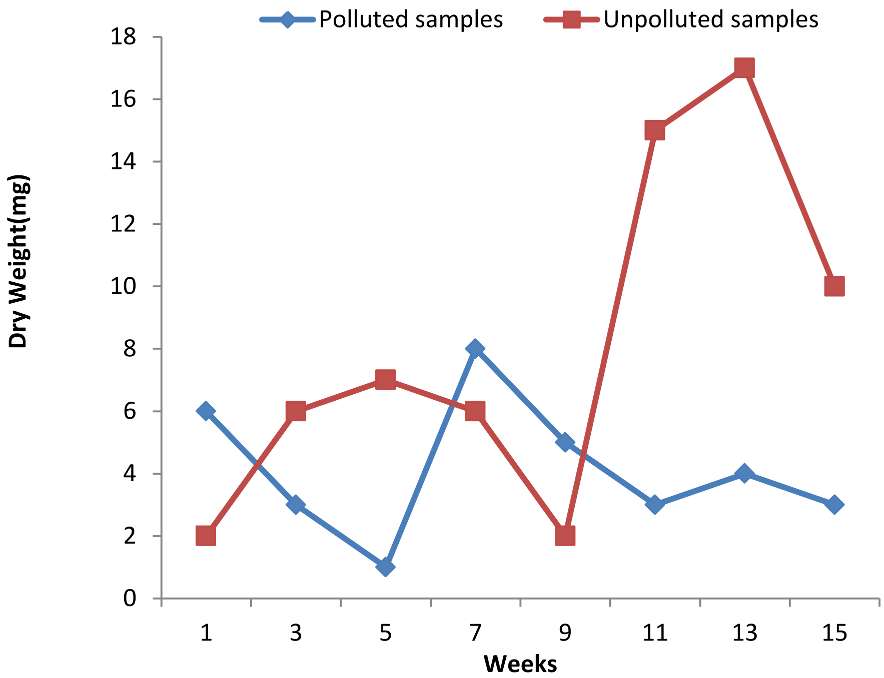


Fig.6: Shows the dry weights of selected shoots (n=10)

*Blue colour represent polluted samples while red colour represents polluted samples.

Figure seven, shows that the moisture contents obtained throughout the experimental week of study (1st to 15th week) varied, that is it was not stable. It was noted that for the polluted samples, the moisture contents was highest in the 13th week (75.00%) and lowest in the 1st week (14.29%). Whilst the unpolluted samples has the highest moisture contents in the 9th week (60%) and the lowest moisture content in the 11th week (16.69%), t-test analysis for the moisture contents **of both samples (Polluted and Unpolluted) revealed that were no significant differences at (P≤0.05).**

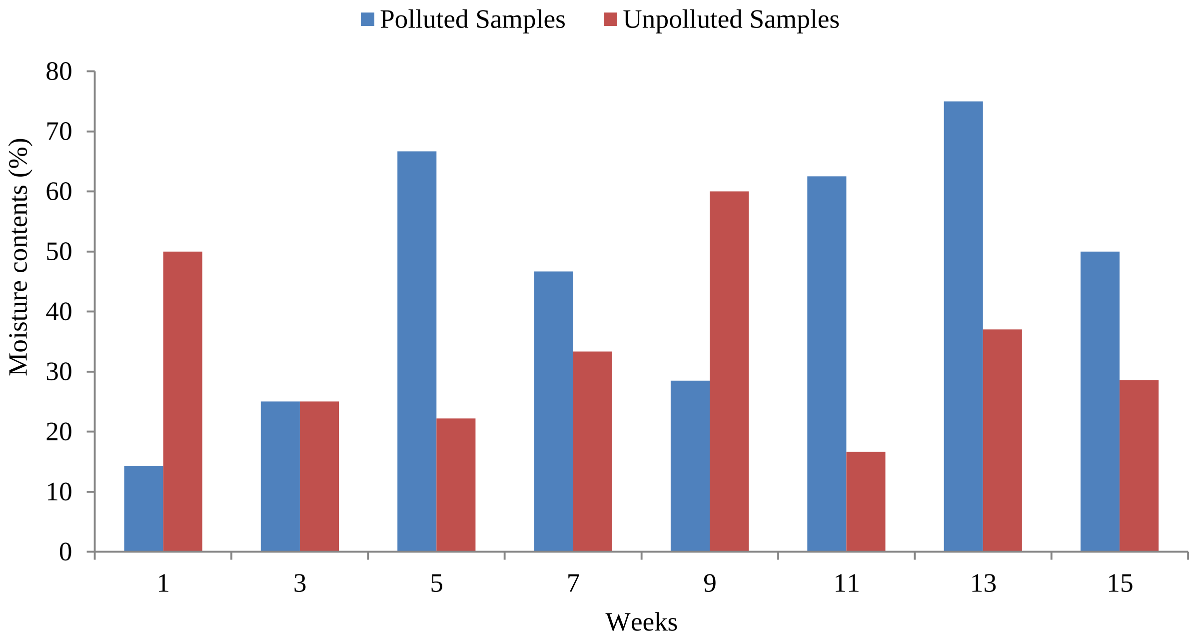


Fig.7: Shows % moisture contents of 10 randomly selected mosses.

*Blue colour represent polluted samples while red colour represents polluted samples.

4. DISCUSSION

The fast growth, precocious reproductive capacity and transient nature of many bryophytes (Bradfield & Sadler 2006) are characteristics which contributes to their being recognized as a model taxon for testing predictions generated by population dynamics theory (Jonsson & Soderstrom 1988). The number of shoots per cm² area (Populations) from the 1st to the 15th week for the unpolluted samples showed an increase, but the rate of growth was slow which agrees with the findings of Keever (1957) and Clymo (1970) which stated that the growth of mosses and liverworts appear to be intermittent and slow. A consequential decrease in the populations of the unpolluted samples must have probably been the influence of environmental pollution on their physiology.

The average number of leaves (n=10) obtainable throughout the experimental periods (15 weeks) showed an increase for the unpolluted ones. The reductions in the average number of leaves for the polluted samples though not enormous, may be attributable to deposition of heavy metals and trace elements on their systems, adversely affecting the accumulation of chlorophyll and hence, a consequential distortion in the leaf primordial. The average height of the plant (n=10) investigated through the period of experimental studies (1st to 15th week) for both samples (Polluted and Unpolluted) seldom exceeded 1cm and this is consistent with findings of Eddy (1990), who asserted that *Barbula indica* is a small bryophyte, green or yellowish, forming low tufts with evenly distributed stems seldom exceeding 1cm in height.

The results of this study showed that abundance of the plant is probably one of the potent factors determining the surface temperature irrespective of whether it is polluted or not. Many bryophytes are remarkably tolerant of desiccation, surviving for weeks or months at moisture contents which may be less 5% or less of their dry weight (Dilks & Proctor 1974). When dry, they survive short period at high temperatures, in some cases 100°C or more (Norr 1974). Deposition of heavy metals and trace elements must have probably increased the moisture contents observed in the polluted samples. The cumulative mean of the dry weights for the unpolluted samples were expected to be less than the polluted samples considering deposition of heavy metals and trace elements in their systems but there was contradiction to this from the results. This probably agrees with the findings of Bates (2000, 2002) that mosses are the least sensitive to the major pollutant of the environment. The greater part of metal contents of mosses is not taken up and is located within the cells but accumulates extracellularly (Richardson 1981).

Observations on innovations in this study may probably indicate that gemma were present abundantly at the base of unpolluted sample. The lack of innovations in the polluted samples may probably be that the level of pollution has affected the reproductive potentials of the plant. Gemma is a means of asexual reproduction (Correns 1899; Cavers 1903) as it has been pointed out by Odu (1987), that the fast spread of *B indica* is attributable to the dispersal and subsequent germination of numerous gemmae from each shoot.

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