***Short Research Article***

# Atmospheric Pressure Change Measurement: An Observational Case Study


## ABSTRACT

**Introduction:** The aim of the study was to show atmospheric pressure change by indirect measurement in hermetically closed vessels during four years follow-up.

**Methods:** Study design: an observational case study. In hermetically sealed elastic bottles with different liquids were measured differences in liquid and air volumes from baseline to four years follow-up period. Physical law of buoyancy was used to measure in each bottles liquid and air (above the liquid) volumes. **Results:** Volumes of liquid and air in all bottles were decreased after the follow-up period to 14.38±2.40 and 36.25±3.37 ml, respectively. Air volumes in comparison to liquid volumes decreased more than two times significantly (P=0.0007) after follow-up period. **Conclusions:** Thus, atmospheric pressure increased for the last 4-year follow-up period. Further investigations are needed.



**Keywords:** Atmosphere pressure; climate change; observation study.




## Introduction

Climate change observed in worldwide in the last several decades. Global annually averaged surface air temperature increased by 1.0°C over the last 115 years (1901–2016). (Wuebbles et al. 2017) Global warming since 1880 has followed a period of rapid acceleration in the past two decades. (National Centers for Environmental Information 2020) Database of NOAA's National Centers for Environmental Information evidences that hurricane activity in the world increased from 1851 to 2020. (NOAA's National Centers for Environmental Information & National Hurricane Center 2020) The 2018 U.S. National

Climate Change Assessment reports that increase in greenhouse gases and decrease in air pollution contributed to an increase in Atlantic hurricane activity since 1970.

Many other aspects of global climate are changing. For instance, changes in surface, atmospheric, and oceanic temperatures; melting glaciers; diminishing snow cover; shrinking sea ice; rising sea levels; ocean acidification; and increasing atmospheric water vapor. (Knutson et al. 2020) Nevertheless, dynamic change in atmospheric pressure (AP) is presented incredibly rare. The aim of the observational study: to show a change in AP by indirect measurement of pressure in hermetically closed vessels for four years.

**Materials & Methods**

The observational study was conducted during four years (October 2016 – September 2020). Study objects: hermetically sealed eight elastic plastic bottles with different liquids: five bottles with non-carbonated drinking water from various manufacturers (#1-5 bottles); one bottle with chemical solvent "646" (#6 bottle); one bottle with drying oil (#7 bottle); and one bottle with alkyd varnish (#8 bottle) (see Table 1).

To reduce a diffusion coefficient for air and liquids the tested plastic bottles were stored for the years in a dark (no light) and cooled (18-20 $^{o}$C) place.

The tested plastic bottles were not opened, not moved during the observational period. Changes in shape of the bottles were evaluated at temperature of 24 $^{o}$C.

Review questions: 1) was there an association between changes in AP and pressure in the tested bottles?; 2) was there an increasing trend in AP?

Due to permeability of liquids and air through PET bottles, (Keller & Kouzes 2017) we measured liquid and air volumes before (baseline) and after (final) the follow-up period. There were measured: 1) Baseline liquid volume; 2) Baseline Total volume (air+ liquid); 3) Final Liquid volume; 4) Final Total volume (air+ liquid); 5) Final Air volume; 6) Differences in liquid and air volumes at the baseline and final.

To measure liquid and air above liquid volumes in each bottle we used the physical law of buoyancy, Archimede's principle, stating that a body immersed in a fluid experiences an upthrust equal to the weight of the fluid displaced. (Randall et al. 2008)

***Statistical analysis.*** Two-tailed Student's t-test with Bonferroni correction was used. The study data are presented in Table as Mean (M), Standard Deviation (SD), and Standard Error of the Mean (SEM), where SEM is SD divided by the square root of the sample size. *P*-value <0.01667 was considered significant as a Bonferroni-corrected *P*-value (98.33%); n=8; the number of tests were performed = 3. Statistical analysis was performed using Excel-2013.

## Results

All eight observed bottles gradually deformed towards flattening during not-opened 4-year follow-up period (see *Appendix*).

*Table 1* shows volumes of liquid and air in all bottles were decreased after the follow-up period to 14.38 ± 2.40 ml and 36.25 ± 3.37 ml, respectively. Air volume in compared to liquid volume decreased more than two times significantly (P=0.0007) after the follow-up period.

## Discussion

Decrease in liquid level in hermetically sealed elastic-plastic bottles during four years can mean evaporation of liquid from the bottle's wall. Whereas an air volume decrease in the hermetically sealed bottle (inside the bottle) can mean a change in AP outside a bottle. Contemporary pet bottles have the best anti-permeability performance using active barrier (scavengers) to prevent the reaction with atmospheric substances. (Sangroniz et al. 2019) Our study results showed indirect evidences of AP increasing during 4-year follow-up period based on the inverse relationship between changes in AP and pressure in the tested hermetically sealed bottles.

AP and temperature both are physical factors, which directly influence metabolic activity for every biological body on Earth. (Lopes et al. 2019); (Mota et al. 2020)

In the world in the same place AP also changes in the last few decades. (Bielec-Bakowska 2016) Over the study period (1951-2015), a minor increase in the annual air pressure values (0.17-0.32 hPa/10 years) was identified.

Increasing metabolic rate, in turn, directly increases biochemical reactions in the body. Possibly, the accelerating development of humankind relates to increase in metabolic rate in humankind. A metabolic rate change depends on AP. Weight gaining in a total population also could be resulted due to raised metabolism. Further investigations are needed.

**Conclusions**

The study showed that atmospheric pressure increased for 4-year follow-up period based on a simple indirect measurement of liquid and air volumes in hermetically sealed bottles. Further investigations are needed.

**Data Availability Statement.** Data are available as supporting information for review purposes.

**Study limitations:** The study has several limitations.

First, the study included indirect measurements to show changing of AP.

Second, there were not presented primary pictures of the bottles.

Third, there were not intermediate follow-up time periods.

**List of abbreviations:**

AP: atmospheric pressure

MR: metabolic rate

**Declarations**

**Ethics approval and consent to participate.** Not applicable

**Consent for publication.** Our manuscript does not contain any person's data in any form. All authors of the manuscript affirmed that they had access to the study data and reviewed and approved the final manuscript.

## References


Bielec-Bakowska Z (2016) Long-term variability of the frequency and persistence of strong highs over Poland. Environmental & Socio-Economic Studies 4:12-23

Keller PE, Kouzes RT (2017) Water Vapor Permeation in Plastics, Vol. PACIFIC NORTHWEST NATIONAL LABORATORY, United States

Knutson T, Camargo SJ, Chan JCL, Emanuel K, Ho CH, Kossin J, Mohapatra M, Satoh M, Sugi M, Walsh K, Wu LG (2020) Tropical Cyclones and Climate Change Assessment: Part II: Projected Response to Anthropogenic Warming. Bulletin of the American Meteorological Society 101:E303-E322

Lopes RP, Mota MJ, Sousa S, Gomes AM, Delgadillo I, Saraiva JA (2019) Combined effect of pressure and temperature for yogurt production. Food Research International 122:222-229

Mota MJ, Lopes RP, Pinto CA, Sousa S, Gomes AM, Delgadillo I, Saraiva JA (2020) The use of different fermentative approaches on Paracoccus denitrificans: Effect of high pressure and air availability on growth and metabolism. Biocatalysis and Agricultural Biotechnology 26

National Centers for Environmental Information (2020) Climate at a Glance: Global Time Series. https://www.ncdc.noaa.gov/cag/global/time-series/globe/land_ocean/ann/7/1880-2020?trend=true&trend_base=10&begtrendyear=1880&endtrendyear=2020

NOAA's National Centers for Environmental Information, National Hurricane Center (2020) Costliest U.S. Tropical Cyclones. https://www.nhc.noaa.gov/dcmi.shtml

Randall, Knight, D (2008) Physics for Scientists and Engineers: A Strategic Approach (With Modern Physics), Vol. Addison-Wesley

Sangroniz L, Ruiz JL, Sangroniz A, Fernandez M, Etxeberria A, Muller AJ, Santamaria A (2019) Polyethylene terephthalate/low density polyethylene/titanium dioxide blend nanocomposites: Morphology, crystallinity, rheology, and transport properties. Journal of Applied Polymer Science 136

Wuebbles DJ, Fahey DW, Hibbard KA, Dokken DJ, Stewart BC, Maycock TKe (2017) USGCRP, 2017: Climate Science Special Report: Fourth National Climate Assessment. https://science2017.globalchange.gov/chapter/executive-summary/

Table 1. Liquid and air volumes in the eight bottles at baseline and final of four-year follow-up period

| # bottles | Liquid volume of the bottles, ml | Baseline Total volume (air+ liquid), ml | Final Total volume (air+ liquid), ml | Final Liquid volume, ml | Baseline Air volume, ml (3*-2*) | Final Air volume, ml (5*-4*) | Difference in Liquid volume at Baseline and Final, ml (5*-2*) | Difference in Air volume at Baseline and Final, ml (7*-6*) |
|---|---|---|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| 1 | 600 | 680 | 625 | 590 | 80 | 35 | 10 | 45 |
| 2 | 500 | 555 | 505 | 480 | 55 | 25 | 20 | 30 |
| 3 | 500 | 550 | 500 | 485 | 50 | 15 | 15 | 35 |
| 4 | 500 | 550 | 495 | 480 | 50 | 15 | 20 | 35 |
| 5 | 500 | 560 | 515 | 480 | 60 | 35 | 20 | 25 |
| 6 | 500 | 555 | 510 | 480 | 55 | 30 | 20 | 25 |
| 7 | 1000 | 1090 | 1035 | 995 | 90 | 40 | 5 | 50 |
| 8 | 685** | 1185 | 1135 | 680 | 500 | 455 | 5 | 45 |
| | | | | | | M= | 14,38 | 36,25 |
| | | | | | | SD= | 6,78 | 9,54 |
| | | | | | | SEM= | 2,40 | 3,37 |
| | | | | | | t-test= | | 5,28 |
| | | | | | | Calculated *P*-value= | | 0,0007 |

Abbreviations: M, Mean; SD, Standard Deviation; SEM, Standard Error of the Mean. # 1-4, and 6 bottles are non-carbonated drinking water from various manufacturers; #5 bottle is chemical solvent "646"; #7 bottle is drying oil; and #8 bottle is alkyd varnish (the bottle was initially incomplete). * column # ; ** a bottle was initially incomplete.

**An appendix**

Hermetically sealed non-carbonated original drinking water before the observation.

Hermetically sealed non-carbonated original drinking water after four-year follow-up.

The hermetically sealed eight elastic plastic bottles with different liquids after a not-opened four years observational period (in front and obliquely from above).


Attributes: The #1-4 and #6 bottles are non-carbonated drinking water from various manufacturers; #5 bottle is chemical solvent "646"; #7 bottle is drying oil; and #8 bottle is alkyd varnish (the bottle was initially incomplete). The bottles were evaluated at a temperature of 24 ºC.