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Atmospheric Pressure Change Measurement: An Observational Case Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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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 four-year follow-up period. Further investigations are needed.

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Keywords: Atmosphere pressure; climate change; observation study.

ABBREVIATIONS

AP : atmospheric pressure
MR : metabolic rate

1. 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) [1]. Global warming since 1880 has followed a period of rapid acceleration in the past two decades [2] Database of NOAA's National Centers for Environmental Information evidences that hurricane activity in the world increased from 1851 to 2020 [3] 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 [4]. Nevertheless, dynamic change in atmospheric pressure (AP) is presented incredibly rare. One of the main physical factors for climate system is AP, which could be also changing. The aim of the observational study was to show a change in AP by indirect measurement of pressure in hermetically closed vessels for four years.

2. 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 [5].

The quantification of the volumes of liquids and air in the bottles carried out as follows. The investigated sealed bottles were alternately immersed in a larger container with water completely filled to the brim. The immersion carried out vertically until the complete disappearance of the immersed bottle in it. A mechanical lever over the water container used for the immersion. The volume of displaced water designated as 'Total volume' (air + liquid). The liquid volume in the bottles was measured directly with a graduated beaker in ml. The air volume calculated according to the equation: 'Total volume' minus 'Liquid volume'. The differences in liquid and air volumes were measured in the each bottle at baseline and final. The differences of liquid and air volumes in the bottles were separately summarized for comparison (Table 1).

2.1 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-2020.

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*

3. RESULTS

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

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

4. 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 air volume decreases in the hermetically sealed bottle (inside the bottle) can mean a change in AP outside the bottles. In the study, we used different liquids with different evaporation and viscosity to increase the accuracy and reliability of the measurements: not just water but also chemical solvent and drying oil.

Contemporary pet bottles have the best anti-permeability performance using active barrier (scavengers) to prevent the reaction with atmospheric substances [6].

Our study results showed indirect evidences of AP increasing during four-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 [7,8]. Therefore, it is very important to know changes of the physical factors on our Earth. Our study identified indirect signs of change in AP.

In the world in the same place AP also changed in the last few decades [9]. 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, because the observational study aim was only to identify a change in AP as a part of the climate change [10].

5. CONCLUSIONS

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

6. DATA AVAILABILITY STATEMEN

Data are available as supporting information for review purposes.

7. STUDY LIMITATIONS

The study has several limitations.

First, the study was a small investigation that included indirect measurements to show changing of AP.

Second, the study does not present primary pictures of the bottles.

Third, the study did not have intermediate follow-up time periods.

DISCLAIMER

This paper is an extended version of a preprint document of the same author.

The preprint document is available in this link: https://www.researchgate.net/publication/357374612_Atmospheric_Pressure_Change_Measurement_An_Observational_Study

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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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 °C

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