

## Inspired Air, Alveolar Air & Expired Air

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**Inspired air:** Inspired air is the atmospheric air, which is inhaled during inspiration. Composition of inspired air is given below.

**Table 1.** Composition of inspired air

Air Gas	Inspired Air	
	Content (mL %)	Partial pressure (mm Hg.)
Oxygen	3.60	104
Carbon dioxide	5.30	40
Nitrogen	74.90	569
Water Vapour	74.90	47
Total	100	760

**Alveolar air:** Alveolar air is the air observed in the alveoli of lungs. It is completely different from inspired air. Generally four different reasons are observed between inspired air and alveolar air.

1. Alveolar air is partially replaced by the atmospheric air during each breath.
2. Oxygen diffuses from the alveolar air into pulmonary capillaries constantly.
3. Carbon dioxide diffuses from pulmonary blood into alveolar air constantly.
4. Dry atmospheric air is humidified, while passing through respiratory passage before entering the alveoli.

**Table 2.** Composition of alveolar air

Air Gas	Alveolar Air	
	Content (mL %)	Partial pressure (mm Hg.)
Oxygen	13.60	104
Carbon dioxide	5.30	40
Nitrogen	74.90	569
Water Vapour	6.20	47
Total	100	760

**Renewal:** Alveolar air is constantly renewed. Rate of renewal is slow during normal breathing. During each breath, out of 500 mL of tidal volume only 350 mL of air enters the alveoli and the remaining quantity of 150 mL (30%) becomes dead space air. Hence, the amount of alveolar air replaced by new atmospheric air with each breath is only about 70% of the total alveolar air.

$$\text{Alveolar air} = 350/500 \times 100 = 70 \%$$

**Collection of Alveolar air:** Alveolar air is collected by using Haldane-Priestly tube. This tube consists of a canvas rubber tube, which is 1 m long and having a diameter of 2.5 cm. It is opened on both ends. A mouthpiece is fitted at one end of the tube. Near the mouthpiece, there is a side tube, which is fixed with a sampling tube. Mouthpiece and the side tube are interconnected by means of a three-way cock. By keeping the mouthpiece in the mouth, the

subject makes a forceful expiration through the mouthpiece. Alveolar air is expired at the end of forced expiration. So, by using the three-way cock, the last portion of expired air (alveolar air) is collected in the sampling tube.

**Expired air:** Expired air is the amount of air that is exhaled during expiration. Expired air equals to sum of alveolar air and dead space air. Concentration of gases in expired air is Somewhere between inspired air and alveolar air. Composition of expired air is given below.

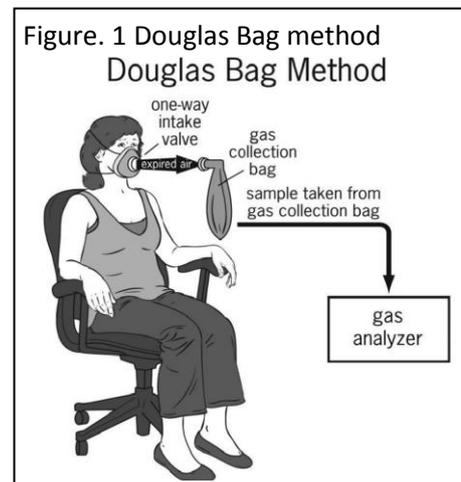
**Table 3.** Composition of Expired Air

Air Gas	Expired Air	
	Content (mL %)	Partial pressure (mm Hg.)
Oxygen	15.7	120
Carbon dioxide	3.60	27
Nitrogen	74.50	566
Water Vapour	6.20	47
Total	100	760

**Method of collection:** Expired air is collected by using Douglas bag (Fig. 1).

**Fraction of inspired oxygen:** With a normal Pa O<sub>2</sub> of 60 – 100 mm Hg and an oxygen content of FiO<sub>2</sub> of 0.21 of room air, a normal P/F ratio ranges between 300 and 500mm Hg.

**Reduced inspired oxygen:** Hypoxemia is denoted as a deficiency of oxygen in the arterial blood. Hypoxemia take place because of ventilation perfusion mismatch, diffusion impairment, hypoventilation, reduced content of inspired air and intrapulmonary or cardiac shunting.



**Meaning of FiO<sub>2</sub> of 100:** The flow meter is linked to either a bottle of oxygen or a medical wall supply of oxygen. This oxygen is pure. It is 100% oxygen. So, anything that comes out of that flow meter shows a FiO<sub>2</sub> of 100%.

**Meaning of FiO<sub>2</sub> 21:** The fraction of inspired oxygen is the concentration of oxygen in the gas mixture at room air shows a fraction of inspired oxygen of 21%, meaning that the concentration of oxygen at room air is 21%.

**Results of breathing expired air:** Breathing of expired air leads to occurrence of elastic property of the lungs and the internal intercostal muscles which decrease the rib cage and reduce thoracic volume. During exhalation, the thoracic diaphragm is relaxed and apply pressure on the lungs for expelling the air.

**Composition of expired air:** An exhaled air consists of nitrogen -78%, oxygen -17 and carbon dioxide - 4 %.

**Expiration of oxygen:** This constitutes 0.04 percent of the permanent gases while taking breath and it is changed to about 4.5 percent of what we exhale. Only 21 percent of oxygen is

inhaled and out of this, exhalation of 15 – 18 percent occurs. The remaining oxygen is sufficient for its requirements.

**Oxygen present in expired air:** Exhaled air consists of more carbon dioxide produced in the form of a waste product of energy production.

**Table 3. Composition of Exhaled air.**

Gas	O <sub>2</sub> % in inhaled air	O <sub>2</sub> % in exhaled air
Oxygen	21	16
Carbon dioxide	0.04	4
Nitrogen	79	79

**Carbon dioxide in expired air:** The expired air consists of high concentration of carbon dioxide (4.2 %) and water (6.2%). The remaining pulmonary air oxygen (15.3%), nitrogen (74.3%) and droplets that are atomized especially on mucous membrane of respiratory tract.

**Difference between expired air and atmospheric air:** Compared to atmospheric air, exhaled air consists of less oxygen, more carbon dioxide and slightly more nitrogen.

**Exhaled air is warmed or not:** Exhaled air warmed normally than ambient temperature. Air in lungs warmed by core body heat and creates a temperature difference between air entering and leaving the respiratory system.

**Expired air consists of more water vapour:** All of the oxygen in the air is consumed by the lungs and expired gases from the lungs are particularly heated to body temperature and show saturation with water vapour and it concludes that exported mid consists of higher water vapour.

**Gases of exhaled breath:** Inhaled air consists of 78% nitrogen, 20.95% oxygen and very low amounts of other gases such as argon, CO<sub>2</sub>, helium, hydrogen and neon. Although CO<sub>2</sub> expelled is only 4% to 5% by volume, but it is about a 100 fold enhancement over the CO<sub>2</sub> inhaled amount.

**Reason for expired air with more oxygen compared to alveolar air:** As expiration continues, the expired air consists of dead space air and alveolar air and only the final part of the expired air is alveolar air. So, the expired air contains more oxygen and less CO<sub>2</sub> compare to alveolar air.

**Water vapour in exhaled air:** The percentage of nitrogen retains at approximately 78% (as we do not have any utility for nitrogen) but the major comparison is an enhancement in carbon dioxide.

**Reasons for expiration:** Expiration takes place during the relaxation of diaphragm. This allows pressure to the thoracic cavity as it lengthens and becomes domed again and at the same time the air is expelled out of the lungs. The relaxation of external intercostal muscles takes place particularly during expiration.

**Expiration from the lungs:** Expiration is the process of expulsion of air out of the lungs especially during the breathing cycle. Especially during expiration, the relaxation of the

diaphragms occurs and elastic recoil of tissue reduces the thoracic volume and enhances the intra alveolar pressure.

**Cause of exhalation of water vapour:** The breath of an individual also consists of moisture especially during exhalation due to the presence of moisture particularly in mouth and lungs.

**Source of water vapour in exhaled air:** The blood consists of some  $\text{CO}_2$  that is transferred to the air in the lungs and later  $\text{CO}_2$  is expelled out. The result is that the exhaled air consists of less oxygen and more carbon dioxide. Compare to the inhaled air. The air in lungs also become humidified along with water particularly before exhalation.

**Cause for more  $\text{CO}_2$  and less  $\text{O}_2$  in exhaled air:** When air reaches the lungs, transfer of some of this oxygen occurs from the lungs to the blood and is transported throughout the body to be utilized for metabolism. Cells produce  $\text{CO}_2$  during substrate oxidation in tissue, which in turn enters the blood and transported to lungs. This fraction of  $\text{CO}_2$  from lungs is again exchanged for oxygen in the inspired air leading to less oxygen and more carbon dioxide in the exhaled air when compared to inhaled air.

### **References**

1. Crystal RG, West JB. The Lung: Scientific Foundations, 2<sup>nd</sup> ed. Raven Press, 1997.
2. Barnes PJ: Chronic obstructive pulmonary disease. New England Journal of Medicine; 343:269, 2000.