Oxygen production potential of trees – unrealistic perception in India

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Photosynthesis is a biochemical reaction which releases oxygen that sustains life on earth. It occurs in all green plants as well as in algae[1]. The recent publication in *Current Science*[2] mentions that the Indian forests have the potential to produce 7896.14 million tonnes of oxygen, signifying it as an ecosystem service. Trees, forests and biodiversity are important elements from a climate change perspective. However, there is a need to introspect on this publication to avoid any misconceptions and misinterpretations. First is the methodology used in the study[2], i.e. the empirical method of Nowak[3]: Net O_2 release (kg/yr) = Net carbon sequestration (kg/yr) × 32/12, with change in a unit from kg yr^{-1} to tonnes ha^{-1} yr^{-1}. Notwithstanding, the authors cite three other papers which narrate different methodologies for estimating the oxygen released and/or produced[4–6]. Despite such glaring inconsistencies in the methodology, the study proclaims that 'net oxygen release was calculated'[2]. Yet, it may be affirmed that this empirical formula will be able to determine the oxygen released so far and not the potential per se. The complexity of estimating oxygen production and the disadvantage of using the empirical equation for the same have been published earlier in *Current Science*[7]. To quote, 'the major disadvantage of empirical equation method is that it does not account for the nature of tree, growth rate, tree architecture or leaf area. For instance, the fast-growing trees like Casuarina will usually have high net oxygen production based on the empirical approach. In real-time, there will be a need to estimate the oxygen production potential of trees rather than estimating the oxygen released so far by the tree'[7]. The authors have also reverberated a similar thought highlighting the fast-growing nature of bamboos and stating it as a species suitable for establishing oxyparks.

It is worth reiterating that the oxygen released by the plants (through photosynthesis) is due to the photolysis of water and not the separation of oxygen from carbon dioxide. Thus, planting trees in urban areas ameliorates the air quality by trapping $PM_{2.5}$, PM_{10} and other pollutants, but not by specifically releasing oxygen. Thus the concept of oxyparks for increasing oxygen concentration in the air needs scientific proof. The publication also states that bamboo releases 35% more oxygen than an equivalent volume of other trees[2], which is again not supported by enough scientific evidence. Moreover, the empirical equations estimate the oxygen released based on carbon sequestrated by the plants. Thus can we extrapolate the same method for other exotic-fast growing trees like *Eucalyptus* sp. and *Acacia mearnsii*?

Secondly, the authors report '… the net oxygen production potential was 28.04 million tonnes per year, of which aboveground oxygen production (25.37 mt yr^{-1}) was more than belowground oxygen production (2.67 mt yr^{-1})'[2]. Roots are the major part of the belowground component where carbon is sequestered as biomass. Does it indicate that tree roots produce oxygen without photosynthesis? This requires more clarity and scientific validation.

Third, the oxygen concentration of the earth has been stable for a long time, i.e. 20.946% and much of its release can be attributed to the oceanic life[8]. Therefore, statements like 'forests and trees are the major source of oxygen and an important reservoir of carbon dioxide' and 'forest canopy is increased and sustained over a period, net carbon dioxide will be removed and more oxygen will be produced'[7] are misleading. This is because the great oxygenation event occurred on the earth even before the trees dominated our planet.

Finally, categorizing states by extrapolating oxygen production potential will confuse the general readers. One fundamental question remains unanswered: since all green plants release oxygen, why the special emphasis on trees?

1. Johnson, M. P., *Essays Biochem.*, 2016, **60**, 255–273.
2. Keerthika, A. and Sangram, C., *Curr. Sci.*, 2022, **122**, 850–853.
3. Nowak, D. J., Hoehn, R. and Crane, D. E., *Arboricult. Urban For.*, 2007, **33**, 220–226.
4. Zhang, L. J., Li, W. L., Jiang, C. Y. and Zang, S. Y., *Int. J. Environ. Sci. Technol.*, 2015, **12**, 4005–4016.
5. Ma, J. Y., Yin, K. and Lin, T., *Acta Sci. Circumst.*, 2011, **31**, 1808–1816.
6. Chen, B. and Lu, S., *J. Zhejiang Univ.* (*Agric. Life Sci.*), 2009, **35**, 686–690.
7. Ramanan, S., Osman, M., Shanker, A. K. and Sridhar, K. B., *Curr. Sci.*, 2021, **121**, 622–625.
8. Livina, V. N. and Vaz Martins, T. M., *The Future of Atmospheric Oxygen*, Springer International Publishing, Cham, Switzerland, 2020.

Response:

This is in response to the concerns raised by Ramanan *et al.* regarding our study[1].

Our publication points out that the oxygen production of trees in India has been quantified based on carbon stock. At present, the empirical method of Nowak *et al.*[2] is the easiest and simplest methodology to convert carbon stock to oxygen production, as it is well accepted by the scientific community. So, there is hardly any issue with the narration presented by Ramanan *et al.* regarding this method.

Estimation of biomass and carbon stock/sequestration was carried out using several methods based on objectives, and it has been well compiled by Newaj[3]. Several researchers have reported errors in the available methodologies due to the type of species, growth rate, edaphic and climatic factors, tree health, age and planting geometry. Even after several scientific advancements, biomass is estimated through volume–density approach, which is non-destructive and gives erroneous estimates.

The error in estimating biomass or carbon is also mentioned by us[1]: 'Again this depends on location, number of trees, diameter distribution, annual timber increment, tree health, age and management techniques.'

The concept of oxyparks or the potential of bamboo to produce oxygen was not proposed by the authors. It is well accepted and implemented by many scientific and government bodies to establish oxyparks mentioned (https://www.thehindubusinessline.com/news/national/oxygen-park-with-beema-bamboo-established-at-tnau/article-30123754.ece). More recently, the Government of Haryana has proposed a scheme of

'Oxy van' to provide a healthy environment and raise awareness about tree planting (https://www.hindustantimes.com/cities/chandigarh-news/karnal-oxy-van-forest-department-releases-9-7-crore-to-power-dept-101645823290476.html).

There are several widely mentioned scientific evidences on oxygen release by trees. According to Salisbury and Ross[4], 'The net oxygen produced is based on the amount of oxygen produced in photosynthesis minus quantity of oxygen consumed at the time of respiration.' The basis of paper is quantification of oxygen production of trees from the most widely used methodology at present. The net annual oxygen production of a tree is directly related to the amount of carbon sequestered by it, which is also associated with the accumulation of tree biomass. It has been quantified using carbon storage of a particular species, irrespective of its nature as indigenous or exotic. So, we can use the same method for other trees as well.

The oxygen production potential was quantified using data provided by the IFSR, Forest Survey of India, 2019. These data were further used to calculate net oxygen production per year based on an empirical formula by Nowak *et al.*[2]. Through photosynthesis, glucose is stored in the form of carbon in different parts of the tree such as stem, branch and root. Therefore, the tree as a whole is involved in photosynthesis. Root hairs help absorb water from the soil and enhance photosynthetic activity. They also help in the repair of damaged tissues in aboveground parts. So, the stored carbon belowground (root portion) must be taken into consideration as the oxygen is produced based on the carbon sequestered. The same was also followed by Nowak *et al.*[2].

Our statements like 'forests and trees are the major source of oxygen and an important reservoir of carbon dioxide' and 'forest canopy is increased and sustained over a period, net carbon dioxide will be removed and more oxygen will be produced'[2] are well accepted among the scientific community. Stancil[5] states that 'A tree has the ability to provide all the essential basic needs of life for all living things on our planet – oxygen, and the power to remove harmful gases like carbon dioxide making the air we breathe healthier.' The earth's forests meet half of the oxygen demand of all people and animals, producing about 26 billion tonnes per year[6]. More interestingly, according to Ramanan *et al.*[7] 'Trees are referred to as the lungs of the earth for their oxygen releasing potential, via photosynthesis'. So, it depends upon the perspective of the reader.

With regard to the special emphasis on trees, they can sequester or store a large amount of carbon in the form of wood. Thus, trees have been given priority over other green plants.

In our study, we have provided valued scientific information about oxygen produced from forests, trees and bamboos to the general readers, which will motivate them to plant more trees.

1. Keerthika, A. and Chavan, S. B.., *Curr. Sci.*, 2022, **122**, 850–853.
2. Nowak, D. J., Hoehn, R. and Crane, D. E., *Arboricult. Urban For.*, 2007, **33**, 220–226.
3. Newaj, R. *et al.*, Methodologies for assessing biomass, carbon stock and carbon sequestration in agroforestry systems. Technical Bulletin 2/2014, 2014.
4. Salisbury, F. B. and Ross, C. W., *Plant Physiology*, Wadsworth Publishing Company, Belmont, CA, 1978, p. 422.
5. Stancil, J. M., 2019; https://www.usda.gov/media/blog/2015/03/17/power-one-tree-very-air-we-breathe
6. Affek, A. *et al*., In *Ecosystem Service Potentials and their Indicators in Postglacial Landscapes*, Elsevier, 2020, pp. 133–289; doi:10.1016/b978-0-12-816134-0.00006-7.
7. Ramanan, S., Osman, M., Shanker, A. K., and Sridhar, K. B., *Curr. Sci.*, 2021, **121**, 622–625.

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