Potentials of Urban Trees and their Roles in Carbon Sequestration

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ABSTRACT

Trees in the urban environments play an essential public health role because of their ability to absorb atmospheric carbon di oxide (CO_2) through photosynthesis and thus, stored CO_2 as tree biomass. Increase in population growth, industries, automobile uses, urbanization, cooking as well as concrete landscape have continued to degrade the natural environment, increasing heat and increasing the amount of greenhouse gas emissions such as CO_2 in the Urban environment. Hence, there is a need to improve urban green efforts. This work reviewed the potentials of urban trees and their role in carbon sequestration. Several approaches have been used to investigate the ability of urban trees to sequester carbon. Their ability to increase carbon sequestration and storage for climate change mitigation actions cannot be overemphasized. Studies have revealed that apart from the direct storing of carbon by urban trees, they as well reduce CO_2 emissions by cooling ambient air and allowing residents to minimize annual heating and cooling. Carbon dioxide concentration due to vehicular emission can also be minimized with roadsides trees. Studies have also exposed that when trees are planted near buildings, they can indirectly reduce carbon emissions by moderating the amount of energy that is required for space cooling. This work concluded that urban dwellers need to recognize and articulate the prominence of trees as a vital component of the urban setting. The selection of different tree species with high biomass and efficiency of trapping and fixing carbon is therefore recommended in plantation programme in urban areas.

INTRODUCTION

The volume of trees to engross carbon dioxide (CO_2) and additional conservatory gases from the atmosphere is known as Carbon sequestration. There is increase in the concentration of CO_2 in the atmosphere which increases anxiety because it is the major greenhouse gas responsible for global warming (IPCC, 2009). CO_2 is the greatest protuberant constituent of anthropogenic greenhouse gas productions, causing primarily from fuel combustion in the urban environment. Increases in human activities such as population growth, industries, auto mobile usage, cooking among others contribute to the growth rate of atmospheric carbon dioxide.

Growth in population with consequent increasing vehicular traffic also has propensities to result in high levels of carbon dioxide in an environment (Bada *et al.*, 2018). Trees alleviate air pollutants and such roles in urban ecosystem need to be taken conscious of as the greenbelt acts as hotspots in urban biodiversity (Sharma *et al*., 2021). Urban trees or vegetation (Kuronuma and Watanabe, 2017) are believed of as an operational ways to mitigate city millennium ecological problems with the comprehended benefits that include urban heat island effect mitigation (Ugle *et al.*, 2010)

Trees do not only have impact on local and regional air quality by fluctuating the atmospheric environment, sinking temperature and other microclimatic effects, dwindling and maintaining air contaminants, and giving cooling effects; nevertheless, also help to resolve, absorb and adsorb particle pollutants that could damage human inhalation tracks, sequester CO_2 and other repugnant gasses and replace the atmosphere with sufficient oxygen (Ondono *et al.,* 2016; Bada *et al.,* 2018). Trees have the capacity to sequester CO_2 through photosynthesis, and can store carbon in the soil (Ngo and Lum, 2018) and in tree biomass.

Carbon storage, as assessed based on tree biomass production, is an effective technique for dwindling the amount of greenhouse gases in the atmosphere (Ritson and Sochacki, 2003; Bada *et al.,* 2018**).** Green areas in the city may significantly affect local concentrations of atmospheric CO_2, showing lower CO_2 concentration in the presence of vegetation. This work therefore reviewed the potentials of urban trees and their roles in carbon sequestration.

Factors responsible for urban increase in carbon dioxide (CO_2) emissions

According to Hoornweg *et al.* (2011) the atmospheric concentration of carbon dioxide has increased dramatically since the start of the industrial revolution. Close to 280 ppmv (parts per million by volume) in 1870, the average global concentration surpassed 400 ppmv for the first time in May 2013. The amount of CO_2 concentration is also growing: from 0.7 ppmv per year recorded in the early 1960s, it rose to 2.0 ppmv per year between 2000 and 2010. This rushing is similar to the rise in fossil CO_2 emissions, due notably to the use of fossil fuels (primarily coal, oil and gas). Cities are responsible for more than 80% of global greenhouse gas emissions (Hoornweg *et al*., 2011).

In Nigeria, Bada *et al.* (2018) in their study reported that industries and vehicular emissions have the tendencies to result in high levels of carbon dioxide in an environment. Ugle *et al.* (2010) reported that cities are net producers of carbon dioxide and have lower amounts of stored carbon.

Ramachandra *et al.* (2015) in their study in the main cities of India, reported that transportation sector was found to be the main source of CO_2 in the urban atmosphere, followed by the domestic and industrial sectors.

In Seoul, Park *et al.* (2013) described peak concentrations and emissions of CO_2 in the early morning and afternoon, in response to the large-scale use of liquefied natural gas for cooking and heating by residents surrounding the measurement site. According to the report of Henninger (2008) on his study in the city of Essen, Germany, more than 70% of the near-surface urban CO_2 was found to be affected by traffic density and atmospheric stability.

Roles of urban trees in carbon sequestrations

Studies have shown that asides struggle to decrease the release of CO_2 in the atmospheres of cities; it is also possible to absorb carbon from the atmosphere and cumulatively trapped it in different components of the urban environment (Ariluoma *et al.*, 2021). This possibility of capturing and trapping carbon is shown in Figure 1 as described by Hyvönen *et al*. (2007) and Fares *et al*. (2017). This application of CO_2 is referred to as carbon sequestration, and urban trees in parks and forested areas can in fact remove and store large amounts of carbon in belowground and above-ground woody biomass (Ngo and Lum, 2018). Akbari and Konopacki (2005) also reported that when trees are planted near buildings, they can indirectly reduce carbon emissions by moderating the amount of energy that is required for space cooling.

Bada *et al.* (2018) examined carbon sequestration potential of roadsides trees in Abeokuta, Ogun State, Nigeria. They reported that the non-green spaces zones had ($p < 0.05$) higher CO_2 and other gases compared to the green spaces zones. Their research revealed that the highest Above Ground Biomass (ABG) value of 66.82 × 106 kg m^2 was estimated in *Azadirachta indica* while highest carbon sequestration of 14273.00 kg m^2 was calculated for *Gmelina arborea*. The study concluded that carbon dioxide (CO_2) concentration due to vehicular emission reduced with roadsides trees.

According to Lai and Augustine (2012) and Nowak (2010), urban trees influence local climate, energy use, carbon cycles and climate change. Other factors that influence the total amount of carbon sequestered by urban trees include: the disposal or use of trees for building construction, number of trees and their spatial coverage, interaction with the soil, age and health and mortality rate. Urban trees can be used to investigate the general condition of any environment. It is a determinant of how anthropogenic activities affect environmental conditions in any cities, assuming that the atmospheric concentration will continue to rise due to anthropogenic emissions. Despite extensive evidence of the critical role played by urban trees in city environments, urban planners and architects have often undervalued the role played by trees.

Ugle *et al.* (2010) and Calfapietra *et al.* (2015) reported that if the cities of the future must be made more sustainable, man must learn to minimize and manage some ecological effects such as urbanization which affects hydrology as well as increase in biodiversity. These will help urban trees to sequester CO_2 under future climates if taken into consideration.

- There are other important benefits of urban trees which are:
- Enhancement of urban climate excesses and mitigation of urban heat islands
- Stock and repossess carbon
- Reduce noise pollution and improve air quality
- Reduce consumption of electricity for heating and cooling
- Aesthetic contribution, scenic beauty, visual amenity, and improve property value
- Contribute to human health and relaxation, reduce stress and anxiety levels

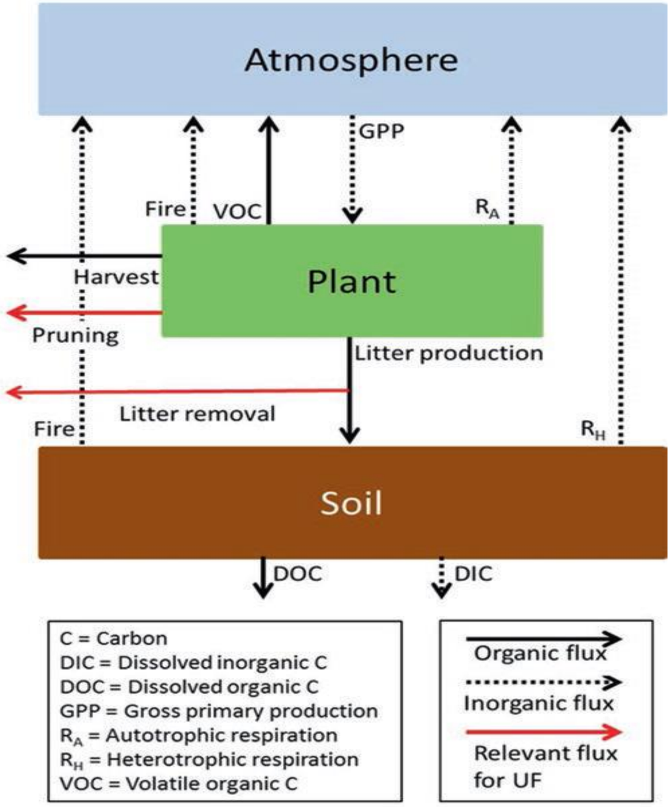

Figure 1: Carbon flow in the soil-plant-atmosphere continuum. Carbon is exchanged in both organic and inorganic form. Red arrows show C fluxes of particular interest in urban forests where trees are managed more intensively with pruning and litter removal (Hyvönen *et al*., 2007; Fares *et al*., 2017).

Carbon Sequestration Potential of urban trees

Urban trees offer various ecosystem services to urban dwellers which include carbon storage and sequestration. During photosynthesis, trees transform carbon dioxide and water into sugar molecules and oxygen, some of this sugar is stored, while most of it gets used by the tree for other purposes such as energy and structure (Nowak and Crane, 2002). One tonne of carbon storage in the tree therefore represents removal of 44/12 or 3.67 tonnes of Carbon from the atmosphere, and the release of 2.67 tonnes of oxygen back into the atmosphere (Nowak and Crane, 2002). Carbon sequestration and storage by trees have been acknowledged as the foremost contributor to carbon soil sequestration of green infrastructure.

The carbon binding capacity and storage are directly dependent on the leaf area and biomass of a plant, and thus over different vegetation types, trees contribute to carbon storage highest (Calfapietra *et al.,* 2015). Sharma *et al.* (2021) revealed that trees have the highest ability for carbon sequestration because of the large biomass whereas the impact of other greenery is small. However the quality and depth of growing medium of other vegetation types impact on the overall carbon storage potential. In particular, a significant increase in carbon storage is achieved by adding biochar to the growing media of all vegetation types Ariluoma *et al.* (2021).

According to the report of Ariluoma *et al.* (2021) optimizing the number of tree species would increase the total carbon sequestration of trees by 95% during 50 years depending on sun and shade conditions. Eneji *et al.* (2014) reported that *Azadirachta indica* and *Albizia lebbeck* stored 5448.8 kg C and 1040.4 kg C respectively in their study area in Nigeria. Ajani and Shams (2016) revealed that *Azadirachta indica* stored 662.3 kg C, and *Conocarpus erectus* 192.7 kg C in their study in Pakistan. Bada *et al.* (2018) also investigated carbon sequestration potential of urban trees in Abeokuta, Nigeria. They reported that the non-green spaces zones had higher CO_2 and other gases compared to the green spaces zones. Their study concluded that carbon dioxide (CO_2) concentration due to vehicular emission reduced with roadsides trees.

In India, Sharma *et al.* (2020) revealed that *Ficus benjamina* can sequester 30.53 tons of carbon. Al-Nadabi and Sulaiman (2023) also reported in their study to screen the tree species diversity in planted vegetation areas for the carbon storage potential that the highest contribution of carbon sequestration (CO_2 equivalent) is dominated by *Ficus spp.* (30.3%) with a total of 3399.3 tCO_2eq, followed by

Azadirachta indicia (25.4%) with a total of 2845.2 tCO_2eq and *Conocarpus erectus* (20.4%) with a total of 2286 tCO2eq. The whole study site had the ability to sequester about 11,213.3 tCO_2eq and 3.9 ± 0.1 tCO_2eq on average. They also reported that it is important have vegetation that can be able to store carbon for sustainable environmental preservation of urban areas.

CONCLUSION

Urban residents need to understand the importance of urban trees as a vital component of the urban landscape especially on their potentials to sequester carbon dioxide as well as other noxious gases in the urban atmosphere. Greater attention is needed to be paid to the selection of trees to be planted in urban environment, not just with a view to easy maintenance, but to select an appropriate mix of trees. These trees will bring about ecological integrity and ability to sequester carbon in legible landscapes. This work revealed that an urban trees function in sequestering atmospheric carbon is very imperative. Therefore, the selection of tree species with high biomass and high efficiency of carbon fixation in afforestation programme in urban areas and institutional areas is highly recommended.

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