VEHICULAR EMISSION: CARBON SEQUESTRATION POTENTIAL OFTEAK TREE (TECTONA GRANDIS) IN ABEOKUTA METROPOLIS

Babalola A. A Layenia, T. N. and Lawal N.S**

Agricultural and Mechanical Engineering Department
Olabisi Onabanjo University, Ago-Iwoye, Nigeria

****aybl2002@yahoo.com**

Abstract

The benefits of vehicular carbon emission reduction in the atmosphere are enormous. This paper investigates the effectiveness of a common teak (*TectonaGrandis*) in absorbing vehicular carbon emissions (Vehicular Carbon Sequestration, VCS) in its various forms. Though there are currently no technologies in the direct measurement of the atmospheric carbon sequestration rate in the city, there are various estimation models that could be adapted to monitor vehicular carbon emission. One of such models is the U.S. Department of Energy's (DOE) "Method for Calculating Carbon Sequestration by Trees in Urban and Suburban Settings". The selected study area is the Abeokuta metropolis. Vehicular population and emission data from 2005 to 2009 was used for this study. The Ogun State Emission Control and Monitoring Scheme provided the data for the vehicular population and carbon emission released into the air.

Parameters such as the tree types, growth rate, age of tree and survival factor were used to evaluate the annual sequestration rate for a fast, medium and slow growing Teak tree. The carbon sequestration rates, obtained for hypothetical 100 trees planted in a square kilometre are 165.87lbs (75.23kg), 215.46lbs (97.73kg) 257.60 (116.8 kg) 303.58 (137.70kg) and 352.56lb (159.9kg) respectively for the years 2005, 2006, 2007, 2008 and 2009. Quantitative evaluation revealed that as the tree matured the carbon sequestrated increased; irrespective of soil type, rainfall and land slope. Therefore it was finally suggested that an aggressive tree planting initiative be embarked upon to attenuate the effect of an increasing vehicular population in the metropolis.

Keywords: TectonaGrandis, Vehicular Emission, carbon sequestration potential, Abeokuta metropolis, Vehicular population.

INTRODUCTION

A number of circumstances call for accurate estimates of atmospheric carbon dioxide ($C0_2$); being a major Green house gas (GHG), among others such as methane (CH_4), chlorofluorocarbons (CFCs), nitrous oxide (N_2O), and tropospheric-ozone (O_3).Together, they are believed to be responsible for a latent increase in atmospheric temperatures by the trapping of certain wavelengths of radiation in the atmosphere. (Nowak et al, 2001). Of these gases, CO_2 is of particular significance, because of its effect on the Earth's climate and the nature of its stability; it is a gas that remains active in the atmosphere for a long time. When a quantum of CO_2 is released into the atmosphere, over 50% of it will take 30 years to disappear, 30% will remain for many centuries and 20% will last for several million years (Solomon et al., 2007, Carvajal et al, 2010).

The concentration of atmospheric (CO_2) which is a major constituent of GHG has increased from 278parts per million in the pre-industrial era of 1970to 379parts per million (ppm) in 2005 at an average of 1.9ppm per year (IPCC, 2007; UNEP, 2007).Globally averaged air temperature at the Earth's surface has increased between 0.3 and 0.6 °C since the late 1800s. A current estimate of the expected rise in average surface air temperature globally is between 1 and 3.5 °C by the year 2100 (Hamburg et al., 1997).

With the increasing concern for rising CO_2 concentration, the role of urban trees, as long-term pool for assimilation of atmospheric CO_2 is being realized; hence studies are currently ongoing for assessing the use of forest biomass sinks to sequester carbon as part of a global mitigation effort against global warming.

As urban areas already exhibit climatic differences compared with rural environments, due, in part, to multiple artificial surfaces and high levels of fossil fuel combustion, climate change impacts may be exacerbated in these areas (Nowak, 2000). Atmospheric carbon is estimated to be increasing by approximately 2600 million metric tons annually (Sedjo, 1989).

Though, some chemicals may be reducing atmospheric temperatures (e.g. sulfur dioxide, particulate matter, stratospheric ozone; (Norwak 2009; Graedel and Crutzen, 1989; Hamburg et al., 1997); its accumulation is solely attributed to fossil fuel combustion and unregulated deforestation worldwide (Jana et al 2009; Hamburg et al., 1997).

Trees act as a sink for CO_2 by fixing carbon during photosynthesis thereby converting CO_2 to their forms of food biomass (Jana et al, 2009).

Trees absorb carbon dioxide from the atmosphere through the natural process of photosynthesis and convert the carbon (C) to their leaves, branches, stems, bark seeds, fruits, and roots.

The realization of the effect of carbon dioxide emissions from the use of fossil fuel on the global climate system has further kindled research interests into strategies to optimally reduce the outcome of these emissions. As BaoHuyI et al; (2008) puts it; "the increase of carbon dioxide (CO_2) in the atmosphere is becoming a global concern and the amount of CO_2 sequestration depends on forest type, forest status, dominant tree species and forest stand age."

Another way by which trees act as major CO_2 sink is the capture of carbon from the atmosphere and the processing and storage of the same in the form of fixed biomass during the growth process. Therefore growing trees in urban areas can be a contributor to reducing the concentration of CO_2 in atmosphere by accumulation in the form of biomass (Chavan and Rasal 2010).An observation from a study on pine species planted on cropland in the south-eastern U.S., the rate of carbon storage begins to decline at approximately age 20 and is close to zero by age 100 (Veld and Plantinga, 2005).

A study carried out and reported by Warran and Patwardhan on carbon sequestration potential of trees submitted that the standing biomass in India was estimated to be 8375 million tons for the year 1986, of which the carbon storage would be 4178 million tons.

Human Contribution

Fresh air contains less than 0.04% carbon dioxide. A human's breath contains almost 5% carbon dioxide. Therefore, we are contributing to the problem with each breath we take. Every person's output varies according to the amount of exercise taken, the food consumed, etc., but for the purpose at hand a reasonable figure is that each person exhales 445 liters of carbon dioxide per day (the average of 1000 samples measured by the USDA). In the course of a year this production by one average person represents 704 pounds of carbon dioxide. (Hannan1997)

Based on the facts available it appears that the CO_2 produced in the selected areas, by human respiration and the burning of fossil fuels, is greater than the CO_2 absorption capacity of our young trees. These estimates do not include the substantial CO_2 production by animals or by microorganisms in the soil. Despite the tremendous burning rate of fossil fuel, the oxygen content of the atmosphere has remained stable, probably because of the slightly better than 1:1 ratio of O_2 production to CO_2 absorption.

Increasing the atmospheric CO_2 concentration stimulates the photosynthetic rate of trees and can result in increased growth rates and biomass production (Jana et al, 2009) 1). A car and driver

produce about 5.5 tons of CO_2 per year and, 2) When all fossil fuel is considered, every man, woman, and child can be said to be responsible for 18.7 tons of CO_2 per year.(Jerry Hannan, 1997)

The scope of this study is limited to urban carbon sequestration potential of teak (*Tectona Grandis*) and on vehicular emission in Abeokuta metropolis only.

Statement of Problem

Due to the rising level of urban vehicular emission and its debilitating effect on the human population and on the average climatic condition of Abeokuta on short and long term basis, it is necessary that a sustainable means of balance be devised in order to militate against such harsh consequences if not taken into consideration.

Objective

The precise objective of this work is to estimate the carbon sequestration rate of teak trees with respect to vehicular emission and how to neutralize the adverse effect of the potential health hazard likely to be caused as a result of rising vehicular population in the Abeokuta metropolis. It also aims to reinforce the usefulness of urban tree planting in mitigating the effects of green-house emission especially harmful carbon and to effectively increase air quality and better enhance an aesthetic appreciation of the Abeokuta metropolis- an essential tourist attraction.

Literature Review

Knowing the carbon sequestration rate of tropical trees is useful. It provides a means of assessing the need for sequestration of carbon in wood, leaves, and roots (Cooper, 1983; Specht and West, 2003); and it can be used as an indicator of site productivity, both biologically and economically and to evaluate the net long-term CO_2 source/sink dynamics of forests through time as trees grow, die, and decay. In addition, since human influences on forests (e.g. management) can further affect CO_2 source/sink dynamics of forests through such factors as fossil fuel emissions and harvesting/utilization of biomass. However, increasing the number of trees might potentially slow the accumulation of atmospheric carbon (Moulton and Richards, 1990).

Dombro (2009) noted that managed tree plantations generally produce 20 to 30 times more wood than do natural forests, resulting in higher carbon sequestration rates per hectare.

Studies cited in Science Daily (Science daily.com) showed that natural African tropical forests absorb about 600 kg (1,323 lbs) of carbon per hectare per year.

Much of the early work on tree allometry and development of biomass equations involved conifers (e.g., Ovington, 1957; Ovington and Madgwick, 1959; Baskerville, 1965). As they typically have monopodial growth, strong apical dominance, and consistently tapered boles, most conifers yield allometric equations that accurately predict biomass. Angiosperms, with their less consistent architecture and complicated branching patterns, are more complicated, but they do demonstrate predictable allometric relationships. Examples of single species biomass equations from the tropics include White sell et al. (1988), Stewart et al. (1992) 16 species; Dudley and Fownes (1992) eight species, Fuwape et al. (2001) two species; Ong et al. (2004), Padro´n and Navarro (2004), Swamy et al. (2004), and Saint-Andre´ et al. (2005).

Inevitably, however, species – especially dicotyledonous trees – differ in allometry, wood density, and architecture, all of which can vary during forest inventories and the biomass of individual trees (Cole and Ewel, 2006).

One of the major Tropical Trees plants is Acacia Mangium, a recognized nitrogen fixing tree (NFT).

Human activities, especially the burning of fossil fuels such as coal and oil and destruction of natural forests, increase the level of CO_2 in the atmosphere. Methane and nitrous oxide, produced by agricultural activity and biological processes, are other greenhouse gases that have greater warming impacts per tonne than CO_2. In 2006, Australia's net greenhouse gas emissions was estimated to be 576 million tonnes CO_2-e (Ian et al, 2008).

According to Marcelo et al. (2001) the knowledge of leaf photosynthetic behaviour is needed to understand the carbon cycles of a particular forest ecosystem and to parametrize ecosystem process models that are used as tools for the assessment of sustainable yields from natural and planted forests.

Though urban areas continue to expand, and urban trees play a significant role in environmental quality and human health, relatively little is known about this resource. As a sequester CO_2, urban trees can play a critical role in helping combat increasing levels of atmospheric carbon dioxide. (Nowak et al., 2002)

They also play a huge role in controlling soil erosion and moderating the climate. Trees significantly affect the existence of millions of city dwellers by its tremendous capacity to reduce air pollution level and satisfy provision of shade and cool environment. In addition, urban trees play an important role in ecology of human habitats in many ways. They filter air, water and sunlight as well as provide shelter to animals and promote comfort in recreational area for people. They also slow down wind velocity and storm water, shade homes and business centres to conserve energy. They are critical in cooling the urban heat island effect; thus, potentially reducing the number of unhealthful ozone days that plague major cities in peak summer months. (Oyebade et al 2012).

Krisdianto et al.(2012) identified ecological elements, including the carbon-oxygen balance and thermal comfort, that were potentially relevant in relation to reducing the negative impacts of climate change and at assessing ecological benefits, such as biomass, carbon storage and sequestration and balanced carbon for and oxygen produced from photosynthesis.

Cole and Ewel, (2006) evaluated the Sample size and range of heights of four different tropical trees harvested to determine stature-biomass relationships allometric equations:

$$Y\ I = a(X)\ b \qquad (1)$$

Where Y = Biomass of tree component I,X is the product of one or more dimensions, while a, b are scaling factors. Dimensions used were diameter (squared, d^2), height (h), and, in the case of Euterpe leaf biomass, the number of fronds (f). The single exception to use of this equation was the fit of a non-logarithmic linear model [y = a + b (d2h)] for whole-tree biomass that combined all three dicotyledonous tree species.

H. Kramer and Olden garm, (2011) used The UrbTree model to estimate tree growth within an area where factors as temperature and rainfall can be considered as homogeneous. Also soil was not used as a variable in the model.

Diverse classes and species of trees abound and each has its own unique way of growth and development. To be able to model tree growth without the necessity to specify the tree growth for each specific (sub) varierity a tree classification scheme is created. This scheme reflects specific aspects of the way the tree grows. Table 1.0 shows the classification scheme, this scheme is based on the book 'Stadsbomen vademecumdeel (Janson, 1997). Each subclass in the scheme will yield a factor by which the average tree growth is influenced.

In Nigeria little or no quantitative information is available about the status of urban forests and trees with respect to their carbon absorption rates. However, there is a growing need and interest in quantifying urban forests and trees habitat characteristics such as forest structure and floristic composition with species diversity and richness indices in different urban areas (McPherson,

1996; Johnston, 1997; Johnston and Rushton, 1999). Jana et al. (2009) measured the carbon sequestration rate and aboveground biomass carbon potential of four young species of *Shorearobusta*, *Albizzialebbek*, *Tectonagrandis* and *Artocarpusintegrifolia*.

Lal et al. (2000) reported that estimated annual carbon uptake increment by Indian forests and plantations had been able to remove about 0.12 gigatons of CO_2 from the atmosphere in the year 1995.

Table 1: Tree Classification

Main Classes	Sub Classes
Size Class (Size of full grown tree)	Small(< 8 meters high),Regular(8-15 meters high), Big(>15 meters high)
Shape Class	Column (height>> width) Vertical ellipse(height>width) Round(height ≈ width) Horizontal ellipse(Height <width) 
Growth Type	Slow, Regular or Fast
Life Phase	Young, Mature or Old

Source: (H. Kramer and Oldengarm, 2011)

Carbon Sequestration

Trees remove carbon dioxide from the atmosphere through the natural process of photosynthesis and store the carbon (C) in their leaves, branches, stems, bark and roots. Approximately half the dry weight of a tree's biomass is carbon. It has been estimated that one tonne of Carbon equals 3.67 tons of 'carbon dioxide equivalent' (CO_2-e) (Johnson et al, 2010).

The absorption of CO_2 by plants constitutes an important element in the global balance of carbon (C). On a global scale it is estimated that the Earth's biosphere takes up nearly 2,000,000 tons of CO_2 per year (UNESA, 2005).Increase in the atmospheric CO_2 concentration accelerates the photosynthetic rate of trees and can result in improved growth rates and biomass production. Results from free air CO_2 enrichment (FACE) experiments show a 25% increase in growth in twice normal concentrations of CO_2. Growth is therefore almost always higher in air with an elevated concentration of CO_2 (Burley et al., 2004).

Trees in forests, including plantations, if well-stocked, typically sequester carbon at a maximum rate between the age of 10 and 30 years. As an indication, at age 30 years, about 200 to 520 tons CO_2-e are sequestered per hectare in forests with productivity ranging from low to high (Australian Greenhouse Office 2001). After this age, if the trees are not harvested, the sequestration rate slows gradually until maturity at about 80 to 100+ years of age, and flattens out from then on as growth is balanced by decay (Johnson et al 2010).

METHODOLOGY

The US department of Energy (1998) presented a method for calculating the amount of carbon sequestered by trees planted individually in urban or suburban setting. This method is appropriate only for calculating carbon sequestration by individual ("open grown") trees, such as trees typically planted along streets, in yards, and in parks To use this method, we need to know the species , year planted, and the age of trees when planted. Broad assumptions have been made regarding sequestration and mortality. The inputs required for the model include the species planted, which allows for consolidating species with similar growth rates, the year planted, and

the age of the tree when planted. Results of the model are reported in total pounds of sequestered by species or group from within a given year planted.

Ambient CO_2 concentration was monitored using a portable gas analyzer model 2000, made in the USA, the equipment is placed five meters to the road in each of the areas. The selected areas were Asero, Obantoko, Lafenwa, Kuto and Onikolobo. The criteria for the selection of the study areas were based on population density and traffic congestion. Out of these five areas mentioned, Lafenwa and Kuto have major motor parks, markets, and residential houses. The CO_2level was monitored for three months between 8:00am and 7pm and the total weighted average of CO_2 was calculated.

Although, photosynthesis and respiration occur simultaneously during the day, only respiration takes place during the night time. Therefore, CO_2absorption and CO_2 emission both occur simultaneously during daytime and only CO_2 emission takes place during the night. In this situation, therefore, the carbon sequestration rate by the plant is evaluated as the net balance of photosynthesis and respiration during the day and night time; that is respirated CO_2 by each tree during both day and night are discounted from the total concentration of CO_2 with respect to time. So also, the effect of soil respiration was eliminated to estimate the actual carbon sequestration rate of the plant. Like other factors, the influence of humidity on carbon sequestration rate of the plant was ignored to emphasize the carbon sequestration study (Jana et al; 2009).

The following assumptions were made:

1. It was assumed that a hundred stands of trees be maintained at the end of each year under consideration per square kilometre.
2. That the number of trees per stand at ages 0 and 1 left be at two till the survival factor is achieved.
3. The Fast, medium and short growth rates were considered due to seasonality of rainfall, varying soil types, soil water retention capability, soil fertility distribution and slope of the landed area. These are factors that will affect the growth rate of teak tree.

Study Area

Abeokuta is the largest city and capital of Ogun State in Southwest Nigeria and is situated on coordinates: 7°9’39N 3°20’54E, on the Ogun River and 64 miles North of Lagos. As of 2005, the estimated population Abeokuta and the surrounding area were 593,140 with an annual growth rate of about 2.83 per cent per annum (Adedeji, 2010, Suleiman et al 2011). This implies that by 2014, it is expected that the population of Abeokuta should be about 660,000

RESULTS

Table 2: Average daily concentration of CO_2 in selected areas of Abeokuta

Sample Areas	Average CO_2 Concentration (ppm)
Asero	1125
Obantoko	1140
Lafenwa	1380
Kuto	1120
Onikolobo	1170

Source: Suleimanet al, 2011

Table 3: Number of vehicles, mileage, and total emission in Ogun State

Year	No of Vehicles	Mileage [$\times 10^3$ km]	CO [tonnes]	HC	NOX	CO_2	PM
2005	52350	198	34052	13525	3608	178	208
2006	56132	214	22816	11181	3433	162	190
2007	58341	226	18534	8545	3202	116	134
2008	60248	230	12071	7208	2040	78	92
2009	64153	242	9535	5410	1876	63	52

Source: Ogun State Emission Control and Monitoring Scheme

Where CO- Carbon Monoxide, HC-Hydrocarbon, No_x- Nitrogen Oxides, $C0_2$-Carbondioxide, PM- Particulate matter.

The following worksheet is provided for summarizing the calculations of annual carbon sequestration for tree planting projects in urban planted or suburban areas. Randomly selecting a tree.

Table 4: Medium Growing Teak

A. Species Characteristics			B. Tree Age (yrs)	C. Number of Age (0) tree to plant	D. Survival Factor %	E. Number of Surviving Trees C x D	F. Annual Sequestration rate (lbs./tree)	G. Carbon Sequestered (lbs) E x F
Name	Tree Type	Growth Rate(S,M /F)						
Teak(*Tectona Grandis)*	H	M	0	100	0.873	87.3	1.9	165.87
			1	100	0.798	79.8	2.7	215.46
			2	100	0.736	73.6	3.5	257.60
			3	100	0.706	70.6	4.3	303.58
			4	100	0.678	67.8	5.2	352.56
Total Pounds of Carbon Sequestered								1036.60
Total Pounds of Equivalent CO_2 Sequestered X 3.67								3804.32
Equivalent CO_2 Sequestered in Short Tons /2000								1.90

Type: H = Hardwood, Growth Rate: S = Slow, M = Moderate, F = Fast

Table 5: Slow Growing Teak Plant

A. Species Characteristics			B. Tree Age	C. Number of Age (0) tree to plant	D. Survival Factor	E. Number of Surviving Trees C x D	F. Annual Sequestration rate (lbs./tree)	G. Carbon Sequestered (lbs) E x F
Name	Tree Type	Growth Rate(S, M/F)						
Teak(*Tectona Grandis)*	H	S	0	100	0.873	87.3	1.3	113.49
			1	100	0.798	79.8	1.6	127.68
			2	100	0.736	73.6	2.0	147.20
			3	100	0.706	70.6	2.4	169.44
			4	100	0.678	67.8	2.8	189.84
Total Pounds of Carbon Sequestered								747.65
Total Pounds of Equivalent CO_2 Sequestered X 3.67								2743.88
Equivalent CO_2 Sequestered in Short Tons /2000								1.37

Type: H = Hardwood, Growth Rate: S = Slow, M = Moderate, F = Fast

Table 6: Fast Growing Teak

A. Species Characteristics			B. Tree Age in Years	C. Number of Age (0) tree to plant	D. Survival Factor	E. Number of Surviving Trees C x D	F. Annual Sequestration rate (lbs./tree)	G. Carbon Sequestered (lbs) E x F
Name	Tree Type	Growth Rate(S, M/F)						
Teak(*Tectona Grandis)*	H	F	0	100	0.873	87.3	2.7	235.71
			1	100	0.798	79.8	4.0	319.20
			2	100	0.736	73.6	5.4	397.44
			3	100	0.706	70.6	6.9	487.14
			4	100	0.678	67.8	8.5	576.30
Total Pounds of Carbon Sequestered								2015.79
Total Pounds of Equivalent CO_2 Sequestered X 3.67								7397.94
Equivalent CO_2 Sequestered in Short Tons /2000								3.70

Type: H = Hardwood, Growth Rate: S = Slow, M = Moderate, F = Fast

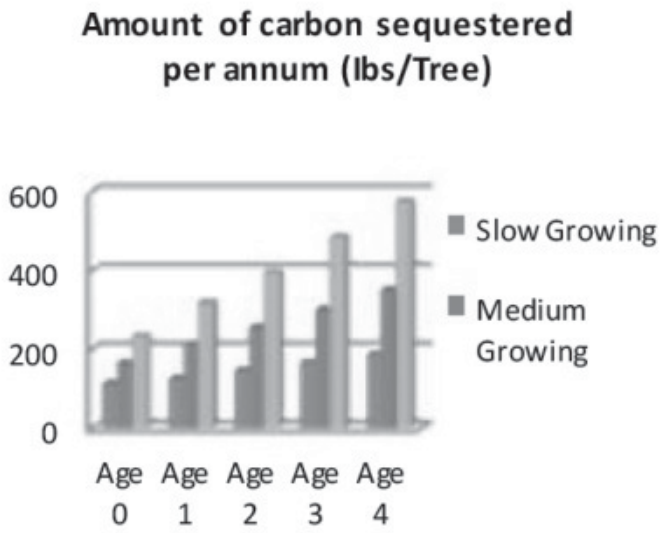

Figure 1: The Carbon Sequestration Rates of *Tectonagrandis* (lbs/year)

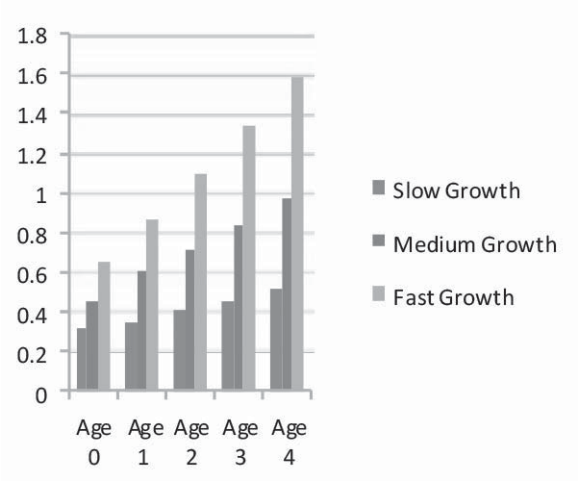

Figure 2: Daily Carbon sequestration rates of *TectonaGrandis (lbs/day)*

DISCUSSION AND CONCLUSION

From the data and figures shown, it can be deduced that teak sequesters carbon dioxide at different rates through the various stages in its development. To represent this, calculations were run for three different situations (Fast, slow and medium growing) teak. Times for each initial planting year, to represent the early, mid and mature age trees. The three sets of calculations were then averaged to represent the average rate of carbon sequestration by year.

The years utilized can be seen in the tables of this report (Tables, 1, 2 and 3).The findings of the study are as follows:

- An estimated average of403.2 pounds of carbon dioxide is sequestered by the planting of each 100 stands annually for a fast growing *TectonaGrandis*
- An estimated total of 7,397.94 pounds (3355.65kg) of carbon dioxide (3.7tons) would have been sequestered by each planting over a period of 4 years for a fast growing tree.

- The concentrations of daily carbon dioxide emission (in parts per million), when converted to pounds, will give approximately0.7614 pounds of carbon dioxide which would have been sequestered by the plantings for years 2006-2009.
- An estimated 13,946.14 pounds of carbon dioxide (6.97 metric tons) would have been sequestered by all of the potential planting efforts.

These results are based upon the numbers provided for plantings, species and percent survival by the plant stand Index, along with the assumptions made by the US DOE described previously. These numbers do not include any below ground carbon, which lends to the conservative nature of our calculations.

Dependent upon the species, management activities and site specifics, it can be confidently asserted that this is a sustainable way to rid the urban atmosphere of toxic carbon emissions.

RECOMMENDATION

It is highly recommended that more studies be undertaken in the area of urban carbon sequestration technologies especially in the validation of carbon data and real time monitoring of the estimated carbon sequestrated values. This research article can serve as a guide to local and state authorities in their urban renewal drive and special planning programmes for the environment. This also can serve as a reference document for the United Nations body on the environment (UNEPA) and all environmentally related bodies as the appropriate prophylactic against global warming and ozone layer depletion.

References

Aguilar and Waldemicks dos Santos Muniz: Evaluating Empirical Mathematical Models to Estimate Leaf Photosynthesis of Tropical Rain Forest Tree Species(2001)

Rostand-Mathieu, A.. Cournède, P.-H de Reffye, P.: A dynamical model of plant growth with full retroaction between organogenesis and photosynthesis

Baskerville, G.L., 1965. Estimation of dry weight of tree components and total standing crop in conifer stands. Ecology 46, 867-869.

Bipal Kr Jana, SoumyajitBiswas, MrinmoyMajumder, Pankaj Kr Roy and Asis Mazumdar. Carbon sequestration rate and above ground biomass carbon potential of four young species; Journal of Ecology and Natural Environment Vol 1(2), 015-024, May, 2009, http:www.academicjounals.org/JENE

Carbon sequestration rate and aboveground biomass carbon www.academicjournals.org/jene/PDF/Pdf2009/.../Jana%20et%20al.pd

Cesar Mota, Carlos Alcaraz-López, María Iglesias, M.C. Martínez-Ballesta and MicaelaCarvajal, Investigation Into $C0_2$ Absorption Of The MostRepresentative Agricultural Crops Of The Region OfMurcia CSIC publications, http://www.lessco2.es

Cooper, C.F., 1983. Carbon storage in managed forests. Can. J. For. Res. 13, 155-166

David J. Nowak, Daniel E. Crane. Carbon storage and sequestration by urban trees in the USA. Environmental Pollution 116 (2002) 381-389 www.elsevier.com/locate/envpol

Dexter B. Dombro 2009 How much carbon does a tropical tree sequester? http://www.sciencedaily.com/releases/2009/02/090218135031.htm

Dudley, N.S., Fownes, J.H., 1992. Preliminary biomass equations for eight species of fast- growing tropical trees. J. Trop. For. Sci. 5, 68-73

Fuwape, J.A., Onyekwelu, J.C., Adekunle, V.A.J., 2001. Biomass equations and estimation for Gmelinaarborea and Naucleadiderrichii stands in Akure forest reserve. Biomass Bioenergy 21, 401-405.

(Garnaut Climate Change Review 2008):www.garnautreview.org.au/chp7.htm). http://wiki.answers.com/Q/How_do_you_Convert_ppm_to_pounds_per_gallon http://www.rcfa-cfan.org/english/issues.13.html

Jerry Hannan, PhD Your Role in the "Greenhouse Effect" *Spring 97 - Volume 28 #2*Institute for Theological Encounter with Science and Technology

H. Kramer, J. Oldengarm URBTREE: A TREE GROWTH MODEL FOR THE URBAN ENVIRONMENT;The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVIII-4/C7.

Ian Johnson and Rebecca Coburn: Trees for carbon sequestration: Prime facts publication, www.industry.nsw.gov.au

Krisdianto, Soemarno, Udiansyah, BagyoJanuwiadi: Standing carbon in an urban green space andits contribution tothe reduction of the thermal discomfort index:a case study in the City of Banjarbaru, Indonesia: International Journal of Scientific and Research Publications, Volume 2, Issue 4, April 2012 1 ISSN 2250-3153 ; www.ijsrp.org

"Method for Calculating Carbon Sequestration by Trees in Urban and Suburban Settings", US Department of Energy, ftp://ftp.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/sequester.pdf.

Ong, J.E., Gong, W.K., Wong, C.H., 2004. Allometry and partitioning of themangrove Rhizophoraapiculata. For. Ecol. Manage. 188, 395-408

Ovington, J.D., Madgwick, H.A.I., 1959. Distribution of organic matter andplant nutrients in a plantation of Scots pine. For. Sci. 5, 344-355.

Ovington, J.D., 1957. Dry matter production by Pinussylvestris L. Ann. Bot. n.s. 21, 287-314. Padro´n, E., Navarro, R.M., 2004. Estimation of above-ground biomass in naturally occurring populations of Prosopispallida (H&B. ex. Willd.) H.B.K. in the north of Peru. J. Arid Environ. 56, 283-292.

Ram Kumar Deo Modelling and Mapping of Above-ground biomass and Carbon sequestration in the cool temperate Forest of North-east China; International Institute for Geo-information science and Earth Observation EnschedeThe Netherlands. March 2008

Saint-André, L., M'Bou, A.T., Mabiala, A., Mouvondy, W., Jourdan, C., Roupsard, O., Deleporte, P., Hamel, O., Nouvellon, Y., 2005. Age-related Trees for carbon sequestration

Solomon, S., D. Qin, M. Manning, R.B. Alley, T. Berntsen, N.L. Bindoff, Z. Chen, A. Chidthaisong, J.M. Gregory, G.C. Hegerl, M. Heimann, B. Hewitson, B.J. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J. Overpeck, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Somerville, T.F. Stocker, P. Whetton, R.A. Wood y D. Wratt. (2007): Technical Summary. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge y New York: Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor y H.L. Miller ed. Pp, 25.

Specht, A., West, P.W., 2003. Estimation of biomass and sequestered carbon onfarm forest plantations in northern New South Wales, Australia. BiomassBioener. 25, 363-379.

Stewart, J.L., Dunsdon, A.J., Hellin, J.J., Hughes, C.E., 1992. Wood biomass estimation of Central American dry zone species. Oxford Forestry Institute, Tropical Forestry Papers No. 26.

Suleiman, M Waheed, M Oni A and Akinyemi.O: Analysis of vehicular emissions and air quality in Abeokuta Metropolis Nigeria; OOU Journal of Engineering and Environmental Studiers Vol2, No1.

Swamy, S.L., Kushwaha, S.K., Puri, S., 2004. Tree growth, biomass, allometry and nutrient distribution in Gmelinaarborea stands grown in red lateritic soils of Central India. Biomass Bioener. 26, 305-317

UNESA, (2005). Forestación y Reforestación. Sumideros de Carbono. En: Metodologíaspara la Implementación de los Mecanismosflexibles de Kioto – Mecanismo de DesarrolloLimpio en Latinoamérica. Rivero Torre, Pedro, León, Gonzalo, Eichhamer, Wolfgang, Deputy, GázquezMateos, José Luis, González Santaló, José Miguel, Ferrando Bravo, Gerardo, Cisneros Gárate, Pablo, Pérez Pallarés, Diego. Capitulo 8.

Whitesell, C.D., Miyasaka, S.C., Strand, R.F., Schubert, T.H., McDuffie, K.E., 1988. Equations for predicting biomass in 2- to 6-year-old Eucalyptus saligna in Hawaii. USDA Forest Service Res. Note PSW-402. www.wikipedia.com/carbonTrees-for-carbon-sequestration.pdf3 How to calculate the amount of CO_2 sequestered – Trees for the Futurewww.plant-trees.org/.../

EFFICACY OF TOOTHPASTE PRODUCED FROM COMBINATION OF SELECTED HERBAL PLANTS IN CAUSING DENTAL CARIES

Onigbinde I. O., Oluyege A.O., and Fabiyi J. S.

Department of Forestry and Wood Technology,
Federal University of Technology, P.M.B. 704Akure, Ondo State, Nigeria

Emails: onigbinde2012@gmail.com; amosoluyege@yahoo.com, andjsfabiyi@gmail.com

Abstract

Toothpastes of different formulations were produced from some selected herbs. Toothpastes produced from the bark of Prosopis Africana, bark of Azadirachtaindica, moringaseeds, Jathrophacurcuslatex and Gmelinaarborea leaves were tested on Streptoccocus mutans, bacteria that causes dental caries. The bark were slashed, washed, dried and pulverized into powder. The seeds and leaves were washed, dried and pounded into powder. Ethanol extraction was done on the bark and all the mixtures were later purified to reduce the microbial load before tested on the bacteria. The effect of the herb was determined in-vitro and the zones of inhibition were measured at 12 hour and 24 hour. The Phytochemical analysis of the herbs were analysed using a standard method. The result showed that plant extract from formulation F (Prosopis Africana) showed the highest zone of inhibition of 20mm at 24 hour and later increased to 24 mm at 48 hours, formulation I (mixture of all the herbs) showed the least zone of inhibition 8 mm at 24 hour and increased to 27 mm at 48 hour.

Keywords: Herbal toothpaste, Dental caries, Streptoccus mutans, Phytochemicals

INTRODUCTION

The oral cavity is a habitat for a large number of micro-organisms species which exist together. Oral hygiene is very important to human health and when neglected, leads to different types of ailments like dental caries and periodontal diseases. Disruptness in the function of the mouth will definitely affect the general well-being of a person by causing considerable pain and discomfort, thus affecting their quality of life. Dental caries is one of the common threats to oral health and is an important public health problem because of its prevalence, their impact on individuals and society, and the expense of their treatment (Beck *et al* 2002).

Oral diseases are caused due to bacterial infections, food habits and life style. It is also observed that the microorganisms found in inflamed gums are resistant to antibiotics but not to antibacterial plant extracts like neem (Maji*et al* 2011). And unlike antibiotics, antibacterial plant extracts produced no allergy in the gingiva (Maji*et al* 2011). One of the common traditional practices is use of herbal chewing sticks' instead of plastic bristle brushes to maintain oral health and hygiene. The best known examples of traditional chewing sticks used are neem and meswak (Mullally *et al* 2008), the end of which is shredded and then used to massage the gums and clean the teeth. Various studies have shown that rural folk in different parts of Nigeria use stem, leaves and fibers of some plants for cleaning teeth, preventing and treating dental caries, gingival and periodontal diseases and other oral mucosal diseases.

Plaque associated with oral disease affects a considerable portion of the population and is considered one of the major causes of tooth loss (Beck *et al* 2002). In most cases, the chronic accumulation of dental plaque often leads to caries and periodontal disease (in genetically susceptible individuals), that may not only affect the patient's oral health, but may also contribute to a number of chronic systemic diseases (Mullally*et al* 2008). It is now well recognized that tooth brushing alone only removes 50% of dental plaque and that additional mechanical

and antimicrobial measures are required to further reduce the bacterial load (Addy*et al* 2008). Although antimicrobials such as chlorhexidine and other chemicals in the form of gels, mouthrinses and varnishes have been proposed as plaque control agents, studies indicate that when dental plaque has formed a mature biofilm, the efficacy of these agents are significantly reduced (Zauri*et al* 2001).

To avoid dental caries due to cariogenic bacteria, inhibition of glucosyl transferase activity by specific enzyme inhibitor (Yanagida et al. 2000), inhibition of initial cell adhesion of *S. mutans* by polyclonal and monoclonal antibodies (Raamsdonk et al.1995) and inhibition of cell growth of *S.mutans* by antibacterial agents have been investigated.

Effective antimicrobial agents against these oral pathogens could play an important part in the prevention of dental caries. However, several attempts to prevent dental caries made were of no practical use up to the present, therefore the purpose of this research is to know the efficacy of herbal toothpaste produced from selected herbs so as to recommend the most effective herbal toothpaste for usage.

MATERIALS AND METHODS

Samples of herbal plants were collected from Ondo and Osun State. *Prosopis africana* (bark) was collected along the express road, Ilesa, Osun State. *Moringa oleifera* (fresh leaves and seed) was taken from Aule road, Akure, Ondo State. *Azadiracthaindica* (bark) and *Jatrophacurcas* (latex), *J. gossyipolia* (latex), *Gmelinaarborea* (fresh leaves and bark) was taken from Federal University of Technology, Akure, Ondo State, Nigeria.

The freshly collected leaves and barks was air-dried under shade (room temperature) to constant weight and then pounded separately using mortar and pestle into smaller particles and later reduced to powder using electric blender (Kenwood). Other materials that were used in this research include baking powder, glycerin, carboxymethyl cellulose (CMC), mint and ginger powder. The chemical reagents that were used include ethanol, distilled water, hydrogen peroxide, ammonium hydroxide, acetic acid and ether; these were purchased from local scientific store.

Extraction procedure

The dried plant material was pulverized into fine powder using mortar and pestle. The air-dried powdered plant samples (200 g of each) was later soaked separately in 400 ml of ethanol in a 500 ml sterile conical flask for 48 h at ambient temperature (35 °C) with vigorous shaking at 6 h for the period of 3 days (Obi *et al.,* 2000).The crude extract was then filtered first using muslin cloth and then using Whatman No. 1 filter paper. Each of the filtrates was evaporated to dryness using rotary evaporator and the dried substance stored in airtight bottles until required (Odebiyi and Sofowora, 1978).

Preparation of microorganism

An infected tooth was collected from a patient in General Hospital, Akure and transported immediately to the laboratory. The tooth was placed in a broth for few hours to dissolve the blood and also to extract all the microorganisms. Blood agar was prepared while bacteria from the broth was streaked on the surface and placed in dessicator for culturing at 37 °C under anaerobic condition. After 24 hours *Streptococcus mutans* was identified through its beta formation and was isolated from other microorganisms in selective agar medium. The desired microorganism was identified using standard microbiological methods (Samy 2000). The Antibacterial activities of the extracts on the isolated organism were determined in the Microbiology Department, FUTA according to the method of Zanpantis*et al*., (2005).

Preparation of Toothpaste

Different toothpastes were produced using different herbs with combination of the following ingredients (Table 1) and tested on the bacteria. Base ingredients:

Baking soda (whitener), Glycerine (humectant), Carboxyl methyl cellulose (binder), Ginger and Menthol (flavouring), Hydrogen peroxide (bleaching agent), Sodium lauryl Sulphite (foaming agent), Water (mixer)

Parts of plant used:

Azadirachtaindica (bark), *Jatrophagossypifolia* (latex), *Jatrophacurcas* (latex), *Prosopis africana* (bark), *Gmelinaarborea* (leaves and root bark) and *Moringa oleifera*(seed and leaves).

Preparation of inoculum

Stock cultures were maintained at 4 °C on slopes of nutrient agar. Active culture for experiments was prepared by transferring a loopful of cells from the stock cultures to test tubes of Mueller-Hinton broth (MHB) for bacteria and was incubated without agitation for 24 h at 37 °C. To 5ml of MHB, 0.2 ml of culture was inoculated and incubated till it reached the turbidity equal to that of the standard 0.5 McFarland solution 8 at 600nm which is equivalent to 106-108 CFU/ml.

Determination of antimicrobial susceptibility of the plant extracts

The anti-bacterial properties of the herbal toothpastes were determined using the agar diffusion method of Bookye-Yiadam (1979). Twenty-four hour broth culture of test organisms (standardized inocula) were swabbed onto sterile Mueller Hinton Agar in petri dishes using a cotton swabs. A stainless steel cork borer of 8mm in diameter was used to make wells on the plates. The holes were filled with the herbs. Each well was labeled appropriately. The extracts were incorporated into the holes by the use of sterile 2 ml syringes.

The culture plates were incubated at 37 °C and antimicrobial activity was determined by measuring the diameters of zone of inhibition around the wells with the aid of a metric ruler and recorded for 24 hours and 48 hours. The antimicrobial studies were done in duplicates and diameters of zone of inhibition (mm) are expressed as means and standard errors on means.

Table 1: Toothpaste formulation

Ingredient	Used (%)
Glycerin	27.0
Baking soda	25.0
H_2O	15.0
CMC	1.4
SLS	2.0
Mint	1.0
H_2O_2	20.0
Ginger	1.0
Herb	10.0
Mixture	1.43

Storage test

The storage ability of the produced herbal toothpaste was determined by testing the inhibitory efficacy of the produced herbal toothpaste on the growth of *Streptococcus mutan* after 2 months of storage in the laboratory conditions (room temperature and relative humidity of about 50%). The toothpaste was stored for 2 months in air tight container.

Phytochemical screening of the plant extracts

Qualitative analysis of the Phytochemical present was carried out using El-Mahmood and Ameh (2007).

Test for Tannins

The samples were stirred in distilled water and filtered. Ferric chloride (0.1 % $FeCl_3$) reagent was added to the filtrate. A blue-black or blue green precipitate was taken as preliminary evidence for presence of tannin (Trease *et al*., 2004).

Test for Alkaloids

A 5 ml of 10 % (v/v) HCL was added to 0.5 g of the samples in the test tubes and put in a water bath for 2 minutes, after which the mixture was filtered. 1 ml of the filtrate was treated with three drops of Dragendroff's reagent in order to separate portions. The presence of alkaloids was confirmed by the production of reddish-brown colouration (Trease *et al*., 2004).

Test for Steriods

Two millimeters (2 ml) of acetic anhydride was added to 0.5 g of the samples with addition of 2 ml of H_2SO_4. A colour change from violet to blue or green indicates the presence of steroids (Trease *et al.,* 2004).

Test for Saponins

One ml extract and one ml alcohol diluted with 20 ml distilled water and shaken well for 15 minutes. The formation of 1 cm layer of foam indicated the presence of saponin.

Test for Flavonoids

A 10 ml of ethyl acetate was heated with plant seed extract in a water bath for thirty minutes. The mixture was filtered and 4 ml of each filtrate was shaken with 1 ml of dilute ammonia solution in a conical flask. A yellow colouration indicates the presence of flavonoids (Harborne, 1998).

Test for Terpenoid

2 ml of chloroform was used to dissolve 0.2g of each sample. Sulphuric acid was carefully added which formed a lower layer. A reddish-brown colour at the interface indicates the presence of terpenoid (Trease *et al*., 2004).

Statistical Analysis of Data

Data were expressed as mean standard deviation. The data obtained were subjected to ANOVA test to determine whether there was significant difference in the time taken for the formulated toothpastes to be effective on the organism and also between the toothpaste.

RESULTS

Anti-bacterial Test

The anti-bacterial activities of nine different toothpaste formulations were investigated against *S. mutans* using standard agar well diffusion method. Each toothpaste formulation exhibited variations in their inhibitory activity. The mean values for zone of inhibition read for the period of 24 hours ranged from 9.33 mm to 20.33 mm while at 48 hours, it ranged from 10.67 mm to 27.33 mm. As illustrated in Table 2, the formulated toothpastes from different herbs reacted differently in reducing the growth of *S. mutans.* Most of the herbs are very effective even after 24 hours. In the zone of inhibition (Table 2), toothpaste G (*Prosobis africana*) has the highest zone of inhibition 20.33 mm at 24 hours while toothpaste I (Mixture of the herbs) has the lowest zone of inhibition of 9.33 mm at 24 hrs while toothpaste I (the mixture of all the herbs) shows the highest zone of inhibition of 27.33 mm at 48 hours and toothpaste A (*M. oleifera* seed) has the lowest zone of inhibition 10.67 mm.