Control of Gaseous Pollution via the Leaves of Non-Edible Trees

Salam J. Bash Al-Maliky
Environmental Engineering/ AlMustansiriya University- Iraq
Salambash2000@yahoo.com

Abstract
The accelerated increase of the use of various transportation means, industrial machinery and other power consuming technologies has led to tremendous degradation of outdoor air quality all around the world. Green solution was tested here as an innovative gas control mean via non edible Myrtus communis green leaves as natural sorption media. Statistical analyses was applied in order to examine the correlation between various parameters of this study. The tests of gas records around the tree that was targeted by a gas stream of 5 KW power generator have demonstrated an excellent gas control role of the green leaves, with average efficiencies of about 75% and 82% for the removal of Nitrogen Dioxide and Carbon Monoxide, respectively. An interesting finding of this research was that the sorption role of green leaves has promoted their sizes and Chlorophyll Content Index.
Keywords: Chlorophyll Index, Green gas control, Myrtus communis, Leaf size, Outdoor pollution, Sorption.

1. Introduction

The control of gaseous pollutants; such as Nitrogen, Carbon and Sulpher Oxides, that are originated from various commercial and industrial uses of fossil fuels as power sources was a big concern for many scientists, researchers, and institutions for decades (CEC, 2005). Although many effective solutions were suggested and implemented in order to onsite emission reduction of these gases from stationary sources, such as air-fuel control and selective non-catalytic reduction (SNCR), the problem is still an issue for the moving sources, in addition to the technical and cost concerns that are related to these mentioned solutions (Moretti and Jones, 2012). From another side, huge efforts and resources were dedicated towards the search of green alternatives for both power sources and pollution control means, as a crucial step for the implementation of global sustainability. Ground heat and aerobic digestion of solid wastes in addition to solar, wind and tide and web sources have demonstrated excellent alternatives for fossil fuels (AlMaliky, 2010, 2011). In parallel to that, many researchers have examined the performance of roots and leaves of indoor plants like dwarf date palm, areca palm and Boston fem, for the control of harmful gas contaminations via absorption process that is followed by converting these pollutants to food that is beneficial for the growth of these plants in turn(Kobayashi et. al., 2007). This reflects the multi role of these plants, as they act as gas control means in addition to being natural filters for the possible surrounding dust, and noise dumpers while supplying fresh Oxygen via photosynthesis process, nevertheless acting as friendly decoration and stress relieving for the inhabitants. The major possible restriction of the use of plants for the control of outdoor gaseous emissions was there durability against high temperatures that are related to various power sources/consumers., hence it is essential to search for proper kinds of plants that are either naturally durable such as Myrtus Communis or artificially made to be so (Bita and Gerats, 2013). Myrtus communis was examined against high temperatures and proved good tolerance for it leaves that emitted mono terpenes; such as α-pinene as a result showed no negative impact on its food metabolism (Alessio et. al., 2004).

1.1 Myrtus communis

It is a highly deficiency lenient evergreen tree with dense flora that has so ancient history of being part of many traditional celebrations and religious rituals for the Mediterranean regions and Middle East nations, as these region`s mostly sunny and humid weather was found to be the perfect for blooming and cultivation of this tree. Its aromatic leaves were finely creased to be used for healing (antiseptic and anti-fever drugs) (Cakir, 2004). Strong emission of isoprenoids was observed by Affek and Yakir (2003), whom reported the storage of monoterpenes in firmly impenetrable structures inside he leaf, detached from photosynthesis. monoterpene emission stimulus was also observed by Loreto et. al., (2004) in the leaves of Quercus ilex that are recovering from ozone stress . The isoprenoids could have been serving as a quenching agent for reactive oxygen species that were formed due to almost all stressful circumstances. Also, Myrtus communis and Viburnum tinus were found resistable and no indications were detected on any of the plants subsequent to 35 days of exposure to 30 ppb ozone (Orendovici et. al., 2003).

Myrtus communis tree shall be tested here as a green widely available and low cost controller for the outdoor gas pollution originated from 5 KW power generator.

2. Setup and methodology

Small household 5 KW, MAC-AFRIC Petrol power generator was adopted to operate 3-5 hours per day as the experimental gas pollutant`s source that was set not less than 25 cm apart from middle aged Myrtus communis bush that almost surrounds the generator. Concentrations of Nitrogen dioxide and Carbon Monoxide were recorded via MX6 iBrid portable multi gas detector, for six months; three times per week, just before and behind the tree in order to determine the role of it as a green gas sorbent. The possible impacts of this setup on some life indicators of Myrtus communis tree were tested by selecting samples of leaves from various locations of the tree in order to record their sizes and chlorophyll content (via CCM-200 plus portable device) prior and after the application of gas stream. The experimental data were statistically analyzed in order to assess the degree of possible correlation between gas reduction and impacts on the tree leaves.

3. Results and discussions

The average of three weekly tests was calculated as a representative of that week to be drawn versus time for each of Carbon monoxide and Nitrogen dioxide gas concentrations just before and behind the Myrtus communis tree, as illustrated in Fig. 1 and 2. The gradual contamination increase of gas emission from the generator as time passes after the start of this study, that is shown in these figures for both gases under study was due to the intentional irregular maintenance in order to account for the highest possible contamination environment. The first 7-10 weeks of operation were observed to have, somehow, fluctuated outlet concentrations for both gases on the other side of the bush in a sign of unstable sorption performance of the tree leaves and this may be attributed to the adapting process against sudden gas streams, after which, leaves tended to show more stable performance as illustrated in the low and semi constant gas concentrations behind the tree. The previous indications were more clarified by Fig.3 and 4, that show low and unstable efficiencies for the first 7 weeks (less than 60s% and 70s% for Nitrogen monoxide and Carbon dioxide gases respectively), however, with an increasing trend towards higher values. That increase rate tended to slow down after the tenth week to show more semi flat form for the rest of study period, in an interpretation of continuous stable control performance of the Myrtus communis tree against such harmful gases with mean efficiencies of about 75% and 82% for Nitrogen monoxide and Carbon dioxide gases respectively.

As regarding the reactions of the tree health indicatore with the contaminated gas stream, Chlorophyll content index CCI was measured for various leaves in order to determine its trend as a result of the sorption of the tested gases, as illustrated in Fig. 5 that infer a slight decrease from CCI initial value of 7.5 to values in the range of 5, has occurred during the first four weeks, followed by sharp upsurge rate during the next few weeks that led to double its original value at the tenth week. The CCI has tended to almost keep that value for the rest of study period in a remarkable indication for the stable gain of gas sorption process for the benefit of photosynthesis process that is exchangeably related to the chlorophyll content. In consecutive action, the leaf sizes of randomly selected samples from all around the gas attacked bush has demonstrated slow gradual promotion for almost all tested ones for the first 16 weeks to reach the size of about 200 mm^2 as compared to their initial size of 120 mm^2, and almost keep that size or little higher for the rest of period of study as shown in Fig.6, which, in addition to the promotion in CCI are strong interpretation for the energetic metabolism process for the conversion of absorbed food into the required chemical energy for plant`s activities, as a result of the gas sorption process.

3.1 Statistical analysis

The previous experimental findings were statistically examined to determine the correlation levels between each pair of the various indicators and parameters of this study; contamination gases, Leaf size, and CCI, and to determine the closest mathematical relations that describe the interrelations, the results of which are tabulated in table 1. The high positive correlation coefficients between each pair of the tested parameters remark a possible causal relation or dependency relations between the sorption of Nitrogen dioxide and Carbon monoxide (as independents) from one side and the promotion of CCI and leaf size (as dependents) from the other one, even though, correlation coefficient (r) does not proof, certainly, that causal, however it boosts further searches. That anticipation of the existence of causal relations between the tree`s health indicators and the sorption of contamination gases was vastly demonstrated by the strong positive correlation between each pair of data in the scatter plots illustrated Fig.7 to Fig.10, which are close to the predicted mathematical relations listed in table 1 with their considerably high coefficients of determination (R^2).

4. Conclusions

The green simple and low cost control of harmful outdoor gaseous emissions of various power producing machines and technologies was studied via the adoption of one of the innovative solutions for this significant consequence of the huge industrialization era, by means of the non-edible Myrtus Communis tree which is a well-known plant in various parts of the world especially the Middle east and Mediterranean sea region. This may be considered as a great step towards global sustainability. The results of 24 weeks test of the mutual effects of gaseous emissions (Nitrogen dioxide and Carbon monoxide gases were selected as representatives of these emissions) as the sorbates and the health parameters of the tree (sorbent), has demonstrated significant performance in the sorption of both gases (average efficiencies of 73% and 82% for NO_2 and CO respectively). In addition to the fact that almost no or little harmful effects were observed on the tree leaves, due to exposure to the contaminated gas stream, the analyzed health indications of these leaves (Chlorophyll content and leaf size) has demonstrated remarkable enhancement by the end of tests period, in a notation of well adaption and beneficial relation between all parameters. The statistical analysis of these data has made a strong support to the previous conclusions as noticed by the high positive correlation coefficients and scatter plots between various pairs of data, in a reference to a highly possible causal relations.

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Table 1. Statistical analysis between various parameters of the study

parameter1 (P_1)	parameter 2 (P_2)	Analysis		
		Predicted relation	Coefficient of determination R^2	Correlation Coefficient (r)
CO removed ppm	CCI	$P_2 = -41.38 + 1.858 * P_1 - 0.0146 * P_1^2$	0.798	0.84
NO_2 removed ppm		$P_2 = -11.78 + 214.02 * P_1 - 387.91 * P_1^2$	0.94	0.90
CO removed ppm	Average leaf size mm^2	$P_2 = e^{(0.02\ P1) * 53.625}$	0.673	0.80
NO_2 removed ppm		$P_2 = e^{(2.62 * P1) * 85.031}$	0.781	0.86

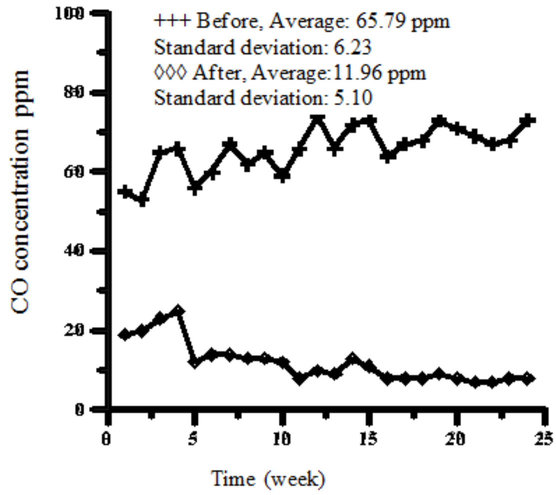

Fig. 1 Role of Myrtus communis in the control of CO gas

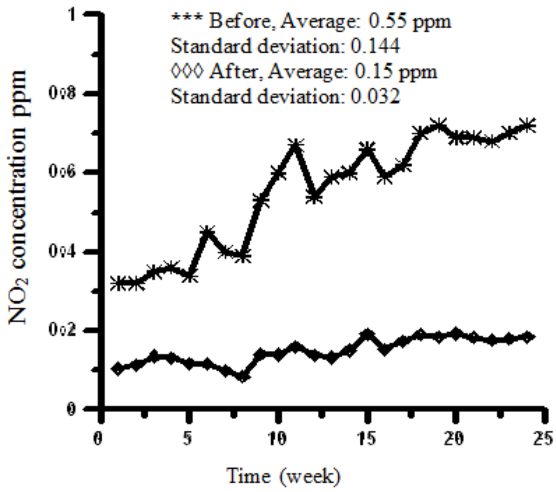

Fig. 2 Role of Myrtus communis in the control of NO_2 gas

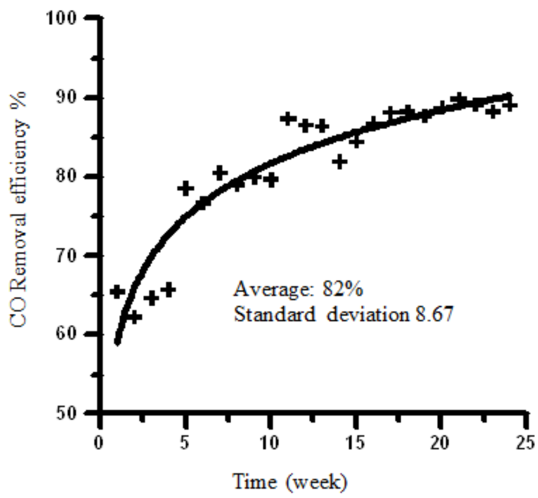

Fig. 3 Removal efficiency of Myrtus communis for CO gas

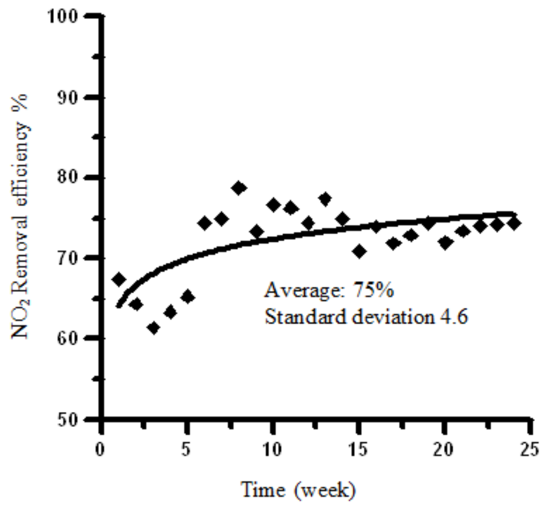

Fig. 4 Removal efficiency of Myrtus communis for NO_2 gas

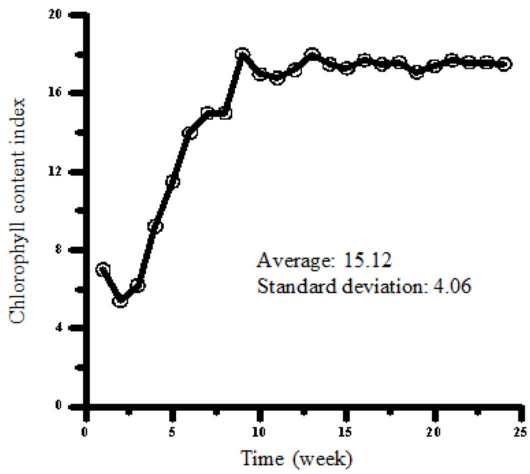

Fig. 5 Myrtus communis tree CCI vs. time

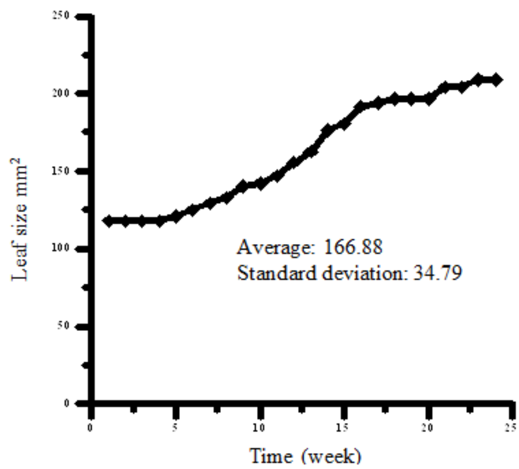

Fig. 6 average Myrtus communis leaf size vs. time

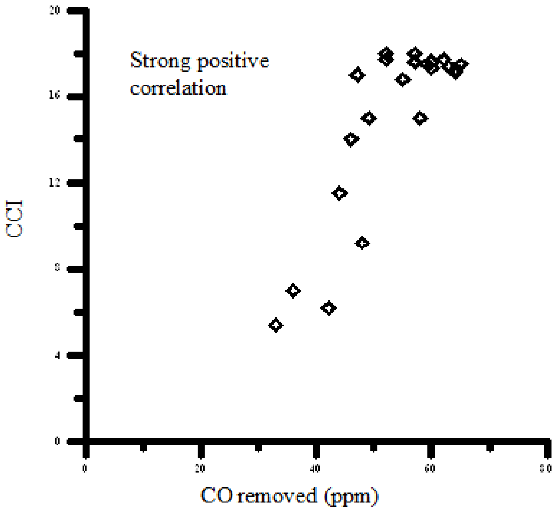

Fig.7 scatter plot of CCI vs. CO removed

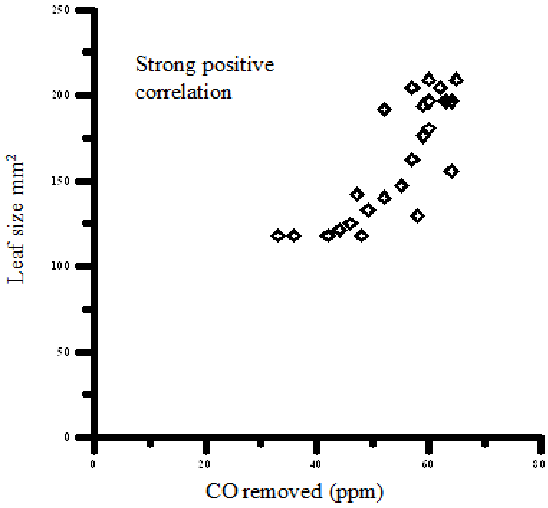

Fig. 8 scatter plot of average leaf size vs. CO removed

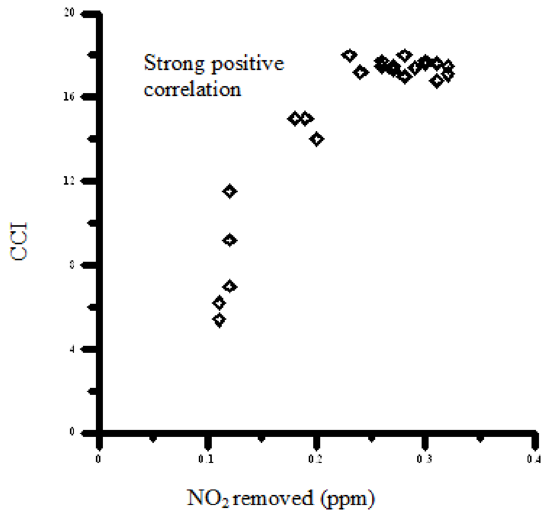

Fig.9 scatter plot of CCI vs. NO_2 removed

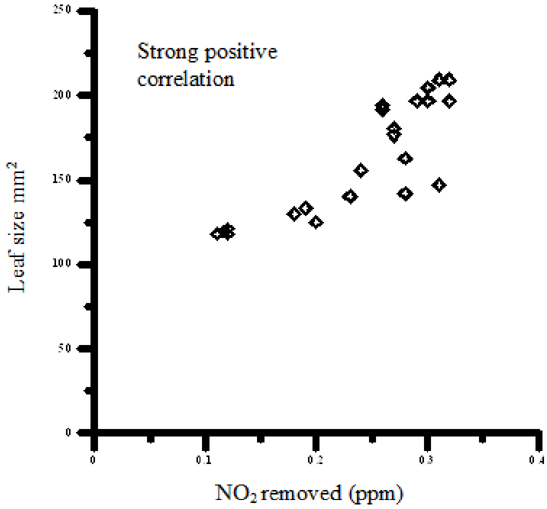

Fig. 10 scatter plot of average leaf size vs. NO_2 removed