VISUAL PHYSICS ONLINE

Experiment PA32A

Growing Trees: Is this a viable solution to the energy problem?

A possible renewable fuel for the future could be the wood from trees. ***But is this a viable option?***

You can carry out a simple experiment to get some evidence to support or reject the possibility of growing trees as an alternative fuel.

Equipment Requirements

A thermometer, tongs, test tube, beaker, water, measuring cylinder, matches (use one match for heating - try to burn the whole match)

Please place burnt matches in beaker to protect table.

At the end, empty beaker in garbage pin and clean beaker and test tube.

Physics knowledge you may require

Density $\rho = m/V$

$\rho_{water} = 1000\ kg.m^{-3} = 1\ g.mL^{-1}$

The amount of energy Q (joules, J) needed to raise the temperature of a material of mass m (kilogram, kg) by ΔT (°C) is

$$Q = m\ c\ \Delta T$$

c is the specific heat capacity of the material.

$c_{water} = 4190\ J.kg^{-1}.°C^{-1}$

Volume of match

$$V = A\ L = L_1\ L_2\ L_3$$

V volume, A cross-sectional area, L length

For a family of 3-4 persons, the typical use of energy for hot water heating is in the order of 4000 kWh per year.

Measurements and Calculations

a) Measure the dimensions of your match.

b) Calculate the volume of your match, V_{match}.

c) Estimate the dimensions of your tree.

d) Calculate the volume of your tree, V_{tree}.

e) Calculate the number of matches in one tree, N_{match}.

f) Add a small volume of water to a test tube. Determine the mass of the water you added, m.

g) Record the initial temperature of the water, T_{i}.

h) Heat the water with the match & record the max. temperature reached, T_{f},

i) Calculate the energy liberated by one match to heat the water, Q_{match}.

j) Calculate the energy from a tree that could be utilised to heat water, Q_{tree}.

k) Calculate the number of joules (J) in one kilowatt-hour (kWh).

l) Calculate the energy in joules required for heating water, Q for a family of 3-4 persons. Assume the energy for hot water heating is 4000 kWh per year.

n) Estimate the number of trees required for the heating water (family), N_f.

o) Estimate the number of trees required for the heating water (Sydney), N_S.

Assume the trees are grown in a forest which has a square shape. Estimate the length of one side of this square, L_S?

Compare your answers with other groups.

What do you think? - is the growing of trees a viable alternative as a fuel?

Sample Results

(a) Measure the dimensions of your match.

$\boldsymbol{L_1}$ **= 43 mm = 43x10^{-3} m** $\boldsymbol{L_2 = L_3}$ **= 2 mm = 2x10^{-3} m**

(b) Calculate the volume of your match, V_{match}.

$\boldsymbol{V_{match} = L_1 L_2 L_3}$ **= (43)(2)(2) x10^{-9} m^3 = 1.72x10^{-7} m^3**

(c) Estimate the dimensions of your tree.

$\boldsymbol{L_1}$ **= 0.5 m** $\boldsymbol{L_2}$ **= 0.5 m** $\boldsymbol{L_3}$ **= 3.0 m**

(d) Calculate the volume of your tree, V_{tree}.

$\boldsymbol{V_{tree}}$ **= (0.5)(0.5)(3.0) m^3 = 0.75 m^3**

(e) Calculate the number of match in one tree, N_{match}.

$\boldsymbol{N_{match} = V_{tree} / V_{match}}$ **= 0.75 / 1.72x10^{-7} = 4.4x10^6**

(f) Add a small volume of water to a test tube. Determine the mass of the water you added, m.

$\boldsymbol{V_{water}}$ **= 30 mL** $\boldsymbol{m}$ **= 30 g = 30x10^{-3} kg**

(g) Record the initial temperature of the water $\boldsymbol{T_i}$ **= 22.0°C**

(h) Heat the water with the match & record the max. temp $\boldsymbol{T_f}$ **= 28.2 °C**

(i) Calculate the energy liberated by one match to heat the water, Q_{match}.

$\boldsymbol{Q_{match} = m\, c\, \Delta T = (30\text{x}10^{-3})(4180)(28.2 - 22.0)\ \text{J} = 7.7\text{x}10^{2}\ \text{J}}$

(j) Calculate the energy from a tree that could be utilised to heat water, Q_{tree}.

$\boldsymbol{Q_{tree} = N_{match}\, Q_{match} = (4.4\text{x}10^{6})(7.7\text{x}10^{2})\ \text{J} = 3.4\text{x}10^{9}\ \text{J}}$

(k) Calculate the number of joules (J) in one kilowatt-hour (kWh).

1 kW = 10^3 W   1 h = (60)(60) s = $3.6\text{x}10^3$ s

energy   1 kWh = $(10^3)(3.6\text{x}10^3) = 3.6\text{x}10^6$ J

(l) Calculate the energy in joules required for heating water, Q.

$\boldsymbol{Q = 4\text{x}10^{3}\ \text{kWh} = (4\text{x}10^{3})(3.6\text{x}10^{6})\ \text{J} = 1.4\text{x}10^{10}\ \text{J}}$

(m) Estimate the number of trees required for the heating water (family), N_f.

$\boldsymbol{Q = N_f\, Q_{tree}}$ $\boldsymbol{N_f = Q / Q_{tree} = 1.4\text{x}10^{10} / 3.4\text{x}10^{9} = 4}$

(n) Estimate the number of trees required for the heating water (Sydney), N_S.

population Sydney = $4x10^6$

number of families = 10^6

$N_S = 4x10^6$

(o) Assume the trees are grown in a forest which has the shape of square. Estimate the length of one side of this square, L_S?

area for one tree $A = (2)(2)\ m^2$

area for all trees $A_{trees} = L_S^2 = (2)(2)(4x10^6)\ m^2 = 1.6x10^7\ m^2$

$L_S = \sqrt{(1.6x10^7)}\ m = 4x10^3\ m = 4\ km$