

Peter's Problem 2015 – The Solution

1. Rainfall in Mullingar:

See: <http://www.met.ie/climate/monthly-data.asp?Num=875>

2012: 1024.2mm

2013: 963.9mm

2014: 1203.5mm

**Average Yearly Rainfall
in Mullingar:**

1063.9mm

Average: $\frac{1024.2+963.9+1203.5}{3} = \frac{3191.6}{3} = 1063.9\text{mm}$ correct to 1 decimal places or 106.39cm.

2. Water harvesting:

Roof Area: $8 \times 8 = 64\text{m}^2 = 640000\text{cm}^2$.

Volume gathered per 1cm of rainfall: $640000\text{cm}^3 = 640$ litres.

Water gathered: $640 \times 106.39 = 68089.6$ litres gathered in 1 year.

Wastage: 3% evaporation + 2% car/garden usage = 5% wastage.

Water harvested: $68089.6 - 5\% \text{ of } 68089.6 = 68089.6 - 3404.48 = 64685.12$ litres = 64685 litres correct to the nearest litre.

Water gathered: 68089.6 litres

Wastage: 5%

Water harvested: 64685 litres

3. Household water usage:

Note: Use 52 weeks per year for weekly usage figures; 365 days per year for daily usage figures.

Kitchen:

Dishwasher: 5 litres; 10 times per week: $5 \times 10 \times 52 = 2600$ litres.

Washing machine: 46 litres; 6 times per week: $6 \times 46 \times 52 = 14352$ litres.

Water tap: 7 litres per min.; 33 min. per day: $7 \times 33 \times 365 = 84315$ litres.

Bathroom:

Cistern full flush: 15 litres; 8 times per day: $15 \times 8 \times 365 = 43800$ litres.

Cistern mini-flush: 6 litres; 28 times per day: $6 \times 28 \times 365 = 61320$ litres.

Bath: 120 litres; 3 times per week: $120 \times 3 \times 52 = 18720$ litres.

Shower: 9 litres per min.; 45 times per week; 3min. 45 sec. each: $9 \times 45 \times 3.75 \times 52 = 78975$ litres.

Hand basin taps: 5 litres per min.; 28 min. per day: $5 \times 28 \times 365 = 51100$ litres.

Total household usage: 355182 litres.

Usage:

Dishwasher: 2600

W/machine: 14352

Tap: 84315

Cistern: 105120

Bath: 18720

Shower: 78975

Basin tap: 51100

Total: 355 182 litres

Q1. Answer: The total household usage is 355 182 litres.

4. The Costs:

Domestic Usage: 355182 litres.

Free usage Allowance: 30000 litres basic; 5 person-household - 10000 litres each: 50000 litres. Total: 80000 litres.

Harvested: 64685 litres.

Billable: $355182 - 80000 - 64685 = 210497$ litres.

First 80000 litres @ 0.05c per litre: $80000 \times \frac{0.05}{100} = \text{€}40$. Total billed so far: 80000 litres.

Next 50000 litres @ 0.09c per litre: $50000 \times \frac{0.09}{100} = \text{€}45$. Total billed so far: 130000 litres.

Next 80000 litres @ 0.14c per litre: $80000 \times \frac{0.14}{100} = \text{€}112$. Total billed so far: 210000 litres.

Next: $210497 - 210000 = 497$ litres @ 0.42c per litre: $497 \times \frac{0.42}{100} = \text{€}2.0874 = \text{€}2.09$ to the nearest cent.

Total bill: Standing Charge €50 + Usage bill ($\text{€}40 + \text{€}45 + \text{€}112 + \text{€}2.09$) = €249.09.

5. The Savings:

Harvested amount: 64685 litres.

The final billable amount was within the 'next 60000 @ 0.42c per litre' range.

$60000 - 497 = 59503$ litres @ 0.42c per litre: $59503 \times \frac{0.42}{100} = \text{€}249.9126 = \text{€}249.91$ to the nearest cent.

Remainder: $64685 - 59503 = 5182$ @ 0.65c per litre: $5182 \times 0.65 = \text{€}33.683 = \text{€}33.68$ to the nearest cent.

Total: $\text{€}249.91 + 33.68 = \text{€}283.59$ [$\text{€}249.9126 + \text{€}33.683 = \text{€}283.5956 = \text{€}283.60$ to the nearest cent.]

Q2. Answer: The total amount saved through harvesting water is €283.59.

Cost	355182 litres:	Remaining litres	Savings through harvesting:
€0	64685	harvested	290 497
€0	80000	free	210 497
€40.00	80000	0.05c/l	130 497
€45.00	50000	0.09c/l	80 497
€112.00	80000	0.14c/l	497
€2.09	497	0.42c	0
€50.00	0	Standing Charge	
Total: €249.09 Bill			Total: €283.59 Savings
			<i>[Note: The total bill without harvesting would have been €532.68]</i>

6. A bill involving leaks:

New Bill amount: €353.68. Old Bill: €249.09.

Increase in bill amount: €353.68 - €249.09 = €104.58.

The final 497 litres of the Old Bill were within the 'next 60000 litres at 0.42c per litre' band. The remaining 59503 litres @ 0.42c per litre would cost €249.09 extra. Therefore, the increase in the bill does not bring the usage of water beyond the '0.42c per litre' band.

Then $104.58 \times \frac{100}{0.42} = 24900$ litres have been lost due to leaks.

Q3. Answer: 24 900 litres have been lost due to leaks.

<p>New Bill: €353.68 Old Bill: €249.09 Increase: €104.58 All within the Band 0.42c/l 24900 litres lost due to leaks</p>
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7. A change in the bill due to a change in rainfall

New bill: €240

Old bill: €249.09.

Reduction in bill: €249.09 - €240 = €9.09.

Rainfall figure of 106.39 cm in a year gives the bigger bill. Therefore there must have been an increase in rainfall to allow more harvesting of water in order to reduce the bill.

Looking at the bands:

The final 497 litres @ 0.42c per litre cost €2.09 which was saved.

€9.09 - €2.09 = €7.00 was further savings.

The previous band of 80000 litres @ 0.14c per litre cost €112 in total. Therefore a fraction of this amount has been saved.

$80000 \times \frac{7}{112} = 5000$ litres have been saved.

Total litres reduced from the billable amount: 497 + 5000 = 5497 litres.

Total increase in harvesting of water: 5497 litres which is 95% of water gathered.

Total increase in water gathered: $5497 \times \frac{100}{95} = 5786.3$ litres = 5786 litres correct to the nearest litre.

Since 640 litres are gathered per cm of rainfall this means that $\frac{5786}{640} = 9.040$ cm of extra rain fell.

Total rainfall: 106.39 + 9.04 = 115.43 cm of rainfall.

Q4. Answer: The actual rainfall for the year was 115.43 cm or 1154.3 mm.

New Bill: €240 Old Bill: €249.09 Reduction: €9.09

Implication: An increase in rainfall with extra harvesting.

From the Old Bill: Remaining to remove: €9.09

€2.09 497 0.42c/l €7.00

€7.00 5000 0.14c/l €0.00

Total: 5497 litres harvested; 5786 litres gathered.

Extra rainfall above average: 9.04cm

Actual rainfall for the year: 115.43cm or 1154.3mm