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Chemistry in a coffee cup: does coffee waste contain key elements for plant growth?

Nitrate answer sheet

Example experimental data:

- Mass of coffee waste sample: 6.34 g
- Volume of water used for extraction: 200 ml
- Dilution 20×: 5 ml coffee extract in 100 ml volumetric flask
- Volume tested of diluted solution with aquarium kit: 5 ml
- Test result: 10 ppm NO_3^- = 10 mg/l (from colour comparison scale)

What nitrate concentration did you observe?

To provide a worked example for the calculations, we use 10 ppm of nitrate in the 5 ml sample.

How many milligrams of nitrates are present in the 5 ml solution analyzed?

From parts per million (ppm) to actual mass in 5 ml: the test result says the solution contains 10 ppm of nitrate. This means that 10 mg of nitrate is found in 1 litre (1000 ml) of water. To find out how much nitrate is in just 5 ml, we calculate a proportion. The result is 0.050 mg of nitrate in the 5 ml sample.

How many milligrams of nitrates were in the 100 ml flask?

The amount of nitrate is 20 times greater because 1/20th of the solution was analysed (5 ml of 100 ml flask). The result is 1.0 mg of nitrate in the 100 ml flask. This is the same content as the original 5 ml taken from the coffee extract (which was used to make the 100 ml diluted solution).

Many milligrams of nitrates were the 200 ml of water extracted from the coffee grounds?

Since 1.0 mg was found in just 5 ml of coffee extract, we now want to know how much nitrate is in the total 200 ml of extract.

We multiply 1.0 mg by how many times 5 ml fits into 200 ml (that's 40 times). So: 1.0 × 40 = 40 mg of nitrate in 200 ml.

40 mg of nitrate comes from 6.34 g of coffee waste that we used.

Assuming all the nitrate was extracted, how much nitrogen will be present in 1 kg of waste?

To find how much nitrate is in 1 kg (1000 g), we scale up:

40 mg ÷ 6.34 g × 1000 g = 6309 mg = 6.31 g of nitrate per kg of waste

Using the molar mass of nitrate (62 g/mol) and that of nitrogen (14 g/mol), the milligrams of nitrogen contained in the nitrate can be calculated; the result is 1.42 g.

Challenge: to match the amount of nitrogen found in a 20 kg bag of commercial fertilizer labelled 20% nitrogen, how much coffee waste would you need?

A commercial fertilizer labelled 20% N contains 200 g of nitrogen per 1 kg of product. This equals 200 g of nitrogen per 1 kg of fertilizer, which means 4 kg of pure nitrogen in a 20 kg bag.

Since coffee grounds contain about 1.42 g of nitrogen per 1 kg of coffee waste, you would need approximately 140 kg of coffee waste to match the nitrogen in 1 kg of 20% N fertilizer.

This shows that, while coffee waste can be a useful natural fertilizer, its nitrogen content is much lower than that of synthetic products.