Environmental Studies
FACTSHEET
www.curriculum-press.co.uk
Number 48

Zinc-cadmium interactions

Introduction

Cadmium is found normally in our soil and water at low concentrations. However, it has many industrial uses - semiconductors, PVC production, batteries, anti-friction agents etc. It is usually mined and extracted from zinc ores, and it is the combination of these two metals that is causing concern. This Factsheet will examine some of the evidence and allow you to practise your skills of experimental design and data interpretation.

Unlike many other pollutants such as organic chemicals or gases, metals such as zinc and cadmium do not break down. Thus, they build up in the soil or in living organisms.

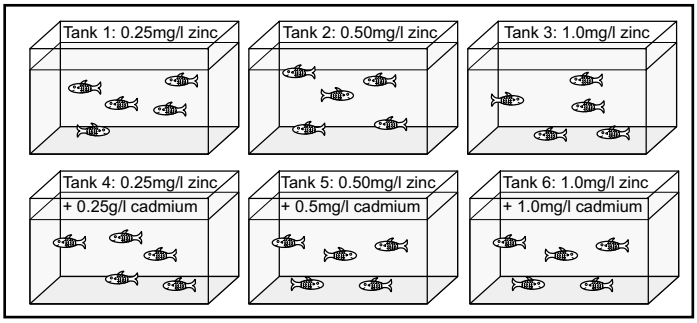
What effect do they have? Well, the answer is that we know about some of their effects, but that we keep on discovering new effects all the time. Many scientists are studying how these metals interact with each other and with other substances.

Case Study 1: The effect of zinc on fish compared to the effect of zinc and cadmium together on fish.

Here's what the scientists did:

1. Fish were reared in tanks containing the following *(Fig. 1)*: They recorded the percentage of fish which died in each tank.

Fig 1



Questions

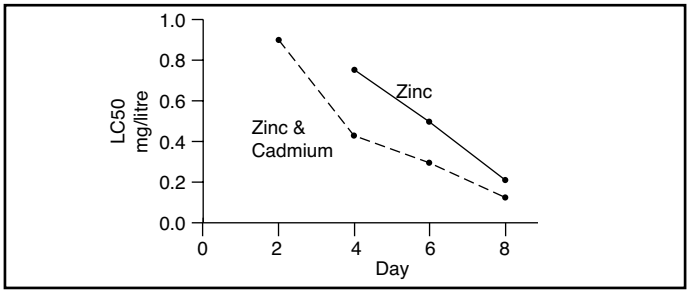
1. Suggest three variables that should have been controlled in order to achieve a fair test. *(3)*
2. Suggest why percentage of fish mortality was recorded rather than the number of fish in each tank. *(1)*

Answers to Questions

1. Water temperature; water pH; water hardness/$CaCO_3$ concentration; all tanks kept for same length of time; mortality recordings taken at same time in each tank
2. In case the number of fish in each tank was not the same initially/easier comparisons;
   - The scientists then calculated what is known as the LC50.
   - This is the concentration of a substance that kills 50% of the organisms being studied (LC = lethal concentration and 50 = 50%).

   Here is a graph of their results *(Fig 2)*.

Fig. 2



What does the graph show?

Because this is a tricky graph, you need to get your eye in.

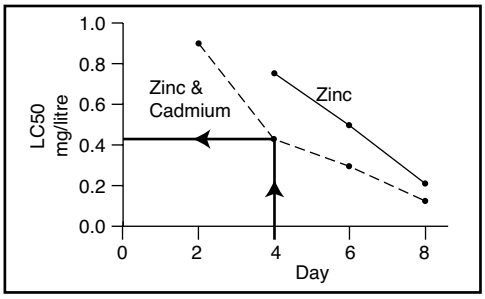
- The bottom axis shows time – the investigation ran for 8 days
- The left hand axis shows the concentration of zinc that killed 50% of the fish.

The two lines in the graph show:

- The concentration of zinc that killed 50% of the fish when only zinc was used (Tanks 1, 2 and 3).
- The concentration of zinc that killed 50% of the fish when zinc was used with cadmium

Fig. 3

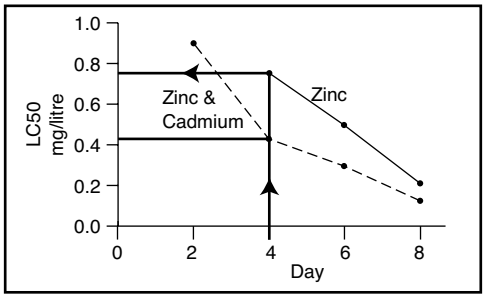
Look at day 4. With a ruler, draw a line up from the bottom axis until it meets the Zn + Cd line. Then draw across to the left hand axis *(Fig. 3)*.



This shows that, by Day 4, when Zn and Cd were present, the concentration of zinc needed to kill half the fish was 0.42mg/l. Now continue the vertical line up to the Zn only line. Then draw across to the left hand axis *(Fig. 4)*.

Fig. 4

This shows that by Day 4, when Zn only was present, the concentration of zinc needed to kill half the fish was 0.76mg/l.



In other words, to kill half of the fish, you need a lot less zinc if cadmium is in there too (0.42g compared to 0.76g). This means that zinc is more toxic to fish if cadmium is in the water as well. The two metals must be interacting.

In fact, from this and other studies, we know that zinc and cadmium act **synergistically**, i.e. if you combine these two metals, their toxic effect is greater than if you simply added together their individual toxic effects.

Is deliberately killing fish ethical?
Could this investigation have been done without harming the fish?

Case Study 2

Can zinc-cadmium interaction harm our food production systems?

Here's what the scientists did:

Wheat plants were grown in soil containing the following:

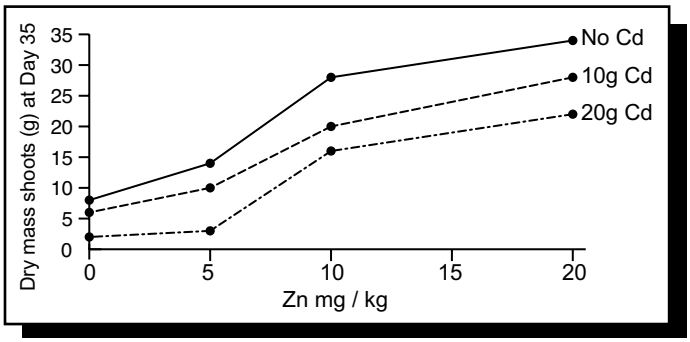
- Soil with no zinc, 5g,10g and 20g/kg zinc
- Soil with no zinc, but 5g,10g or 20g/kg of cadmium
- Soil with 5g/kg zinc and with 5g,10g or 20g/kg of cadmium
- Soil with 10g/kg and with 5g,10g or 20g/kg of cadmium
- Soil with 20g/kg zinc and with 5g,10g or 20g/kg of cadmium

So, all combinations of zinc and cadmium were used. The results are shown in *Table 1* and *Fig. 5*.

Table 1

Zn	Dry Mass	10g Cd	20g Cd
0	8	6	2
5	14	10	3
10	28	20	16
20	34	28	22

Fig. 5



Q1: **Which is most useful in working out what has happened - the table or the graph?**

A: Most people would say the graph, but if you found the table best - ***and your conclusions from it were correct*** - you may be a table-genius.

Write down the answer to each of the following questions **BUT** for each question you can only use a maximum of 15 words

Q2: What is the effect of zinc concentration on the dry mass of wheat seedlings?

A: As zinc concentration increases, dry mass increases

Q3: What does the graph show about the effect of high cadmium concentrations on the dry mass of wheat at 10 days?

A: Nothing. All of the data refers to day 35. The bottom axis shows zinc concentration

Q4: Is there any evidence that cadmium interacts with zinc?

A: Yes. At every concentration of zinc, the presence of cadmium reduces dry mass.

Q5: Would the presence of high concentrations of cadmium be more harmful in soils with low or high zinc? Explain your answer. (All in 15 words!)

A: Low zinc. 20g Cd has a big effect at 0 and 5g Zn.

We need zinc

Zinc is essential for human health:

Our DNA has proteins attached to it and those attachments involve zinc. Zinc is therefore essential in the copying of DNA to make new cells and in the repair of damaged DNA.

There is plenty of evidence that cadmium (and perhaps other chemicals) disrupts these processes by interfering with the action of zinc. Smoking means the mother is more likely to be zinc-deficient. If cadmium is taken into the body during this time, it replaces zinc in metabolic processes. It may be this that is behind the damage caused to the foetus if its mother smokes during pregnancy.

Other functions of zinc in the human body include:

- metabolism of Vitamin A
- immune functions,
- gamete formation
- wound healing.
- protection against the carcinogenic effects of toxic metals such as cadmium
- restoring immune function in cancer patients;

Conclusions

Cadmium can harm organisms. It may do this directly but it can certainly do it by interacting with zinc, a metal that is essential for growth.

Many other metals and non-metals may interact in harmful ways. We need to study these.

Possible Investigations

You can easily set up your own short, or long-term, investigations of interaction. Choose heavy metals or other substances that might realistically get into the soil. Choose sensible plant species. Decide whether you are going to measure seed germination (where the shoot and root appear) or seedling growth. You don't have to use soil - you could grow seedlings in water or on another medium.

Try typing synergism into Search engines like Google, Vivisimo or Scirus for ideas and background info.

Acknowledgements

This Factsheet was researched by Kevin Byrne, Chief Examiner.

Curriculum Press, Bank House, 105 King Street, Wellington, TF1 1NU. Tel. 01952 271318.

ISSN 1351-5136