Plant uptake and the CLEA model

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Next 20 minutes

- Land contamination and risk assessment
- CLEA model
- Predicting exposure from consumption of homegrown produce
  - How much do we eat?
  - How much chemical is taken up by homegrown fruit and vegetables?
- Final thoughts

Managing land contamination

- Land may be contaminated by previous use, by diffuse pollution, or by its natural state
- Agency (2005) estimated that as many as 325000 sites may be ‘potentially affected’
- Managing land contamination:
  - Planning regime
  - Part 2A
  - Other such as ‘due diligence’

CLEA Model

Contaminated Land Exposure Assessment model

HUMAN EXPOSURE TO CONTAMINANTS IN THE SOIL ENVIRONMENT

Predicting how we behave on a contaminated site according to land-use and the extent to which this may lead to exposure to soil contamination for critical receptors (e.g. small children)

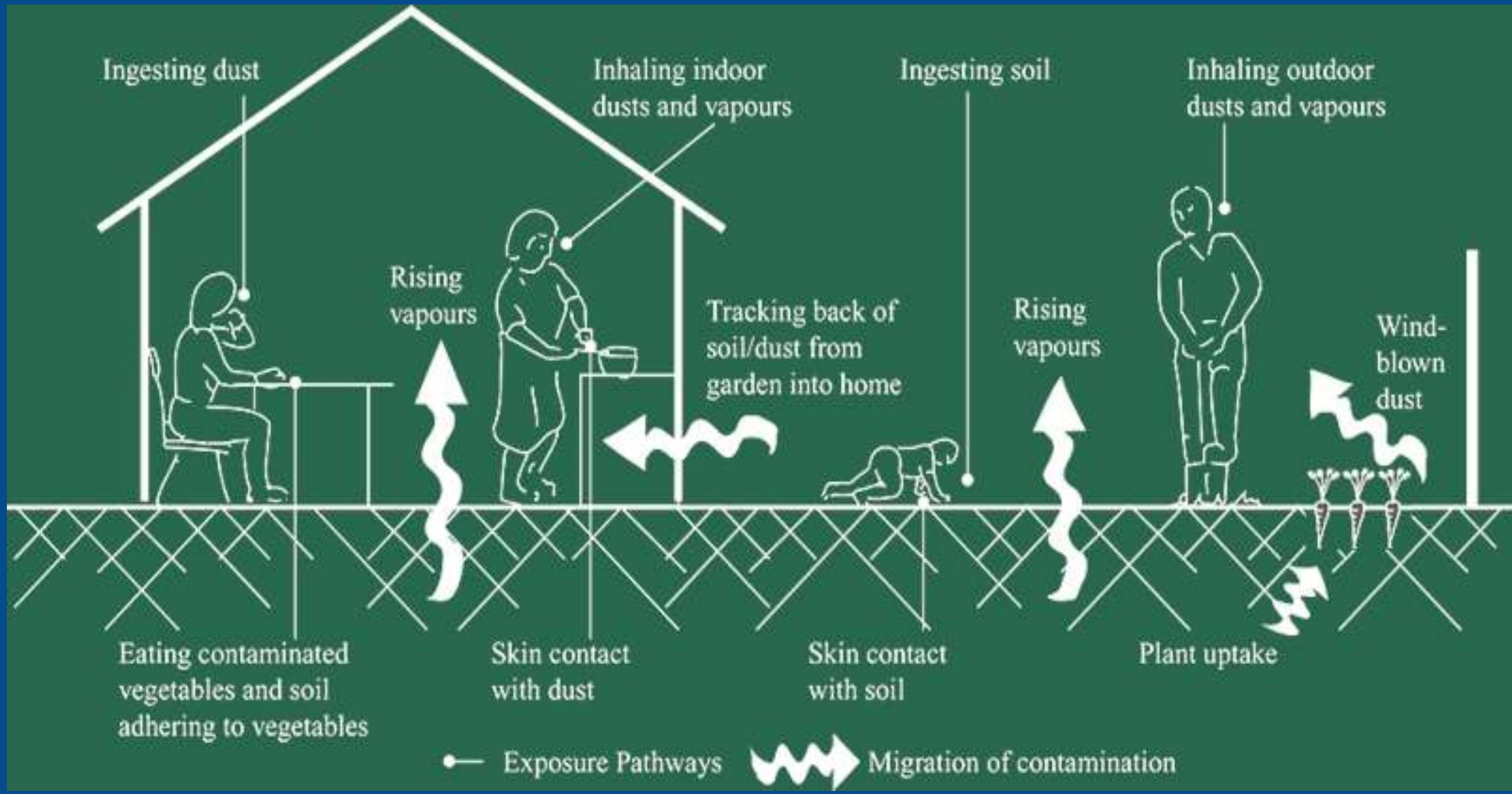
FATE AND TRANSPORT OF CONTAMINANTS IN SOIL ENVIRONMENT

Understanding and predicting how contaminants move within each environmental compartment - air, water, and soil

EVALUATION OF THE RISK TO HUMAN HEALTH ARISING FROM EXPOSURE

Judging the potential risks to health from exposure to contaminants in soil

Exposure pathways



Key questions for the plant pathway

- What do we eat?
- How much do we eat?
- How much chemical is transferred from soil to plants?
- How much is lost / transformed during food preparation?
- How much of the accumulated chemical is still toxic?
- How much chemical is absorbed by the gastro-intestinal system during digestion?

What do we eat?

Produce group	Included crops
Green vegetables	Beans (broad, French, green and runner beans), Brussels sprouts, cabbage (red, white, greens and kale), cauliflower, lettuce, spinach, peas (garden and mange tout), stem vegetables (broccoli, celery, asparagus), okra, globe artichokes, Chinese leaves, endives, chicory, chard, dandelion, watercress and fresh herbs (basil, coriander, tarragon, sage, parsley and mint).
Root vegetables	Beetroot, carrot, cassava, garlic, ginger, Jerusalem artichoke, leeks, onions, parsnips, radish, rhubarb, salsify, swede, sweet potato, turnips and yam.
Tuber vegetables	Potatoes
Herbaceous fruit	Aubergine, courgettes, cucumber, marrow, pumpkin, strawberries, tomatoes
Shrub fruit	Bilberries, blackberries, cranberries, gooseberries, loganberries, mulberries, physalis, raspberries, blackcurrants, redcurrants, and white currants
Tree fruit	Apples, apricots, cherries, peaches, pears and plums

How much do we eat?

- How much do we eat ?
  - Food Standards Agency INTAKE 2 model
  - National Diet and Nutrition Surveys 1992 - 2000
- How much is homegrown?
  - Estimated from Expenditure and Food Survey
  - Incomplete data – especially for high consumer sub-groups

Produce	Homegrown Fraction	
	(average)	(high)
Green veg.	**0.05**	**0.33**
Root veg.	**0.06**	**0.40**
Tuber veg.	**0.02**	**0.13**
Herbaceous fruit	**0.06**	**0.40**
Shrub fruit	**0.09**	**0.60**
Tree fruit	**0.04**	**0.27**

How much space do you need?

- Growing area required for average population consumption rates used in the CLEA model for a family of four is:

Category	Annual Household Consumption (kg fw)	Typical Yields (kg fw m^{-2})	Required Area (m^2)
Green vegetables	16.8	2.7	5.7
Root vegetables	5.7	4.5	2.5
Tuber vegetables	3.0	14.0	0.2
Herbaceous fruit	8.2	2.6	10.6
Shrub fruit	1.5	1.1	1.5
Tree fruit	7.8	2.9	2.9
			23.3

- 85 per cent of residential gardens greater than 100 m^2 and 34 per cent greater than 450 m^2 (MAFF 1999)

Approach to predicting plant uptake

- Soil-to-plant concentration factors on a fresh weight basis
  - Collected from literature reviews using guidelines in Environment Agency (2006)
  - Geometric mean values for a wide range of plant and soil types from edible fractions and at soil concentrations in the critical range
  - Literature data considered along with generic models
  - Attached soil considered separately

$$CF = \frac{C_{plant}}{C_s}$$

CF is the soil-to-plant concentration factor, mg g^{-1} FW plant per mg kg^{-1} DW soil

C_{plant} is the chemical concentration in edible plant tissues, mg g^{-1} FW plant

C_s is the total soil concentration in soil, mg g^{-1} DW soil

Generic model for inorganic chemicals

- PRISM 2
- Dynamic radionuclide model from FSA
- Predicts root uptake ratio and internal plant transport factors for six produce groups

$$CR = \frac{\delta}{(\theta_w + \rho_s K_d)}$$

CR is the soil-to-root concentration factor, mg g^{-1} FW plant per mg g^{-1} DW soil

δ is the soil – plant availability correction for loam soil, dimensionless

θ_w is the water-filled soil porosity, cm^3 cm^{-3}

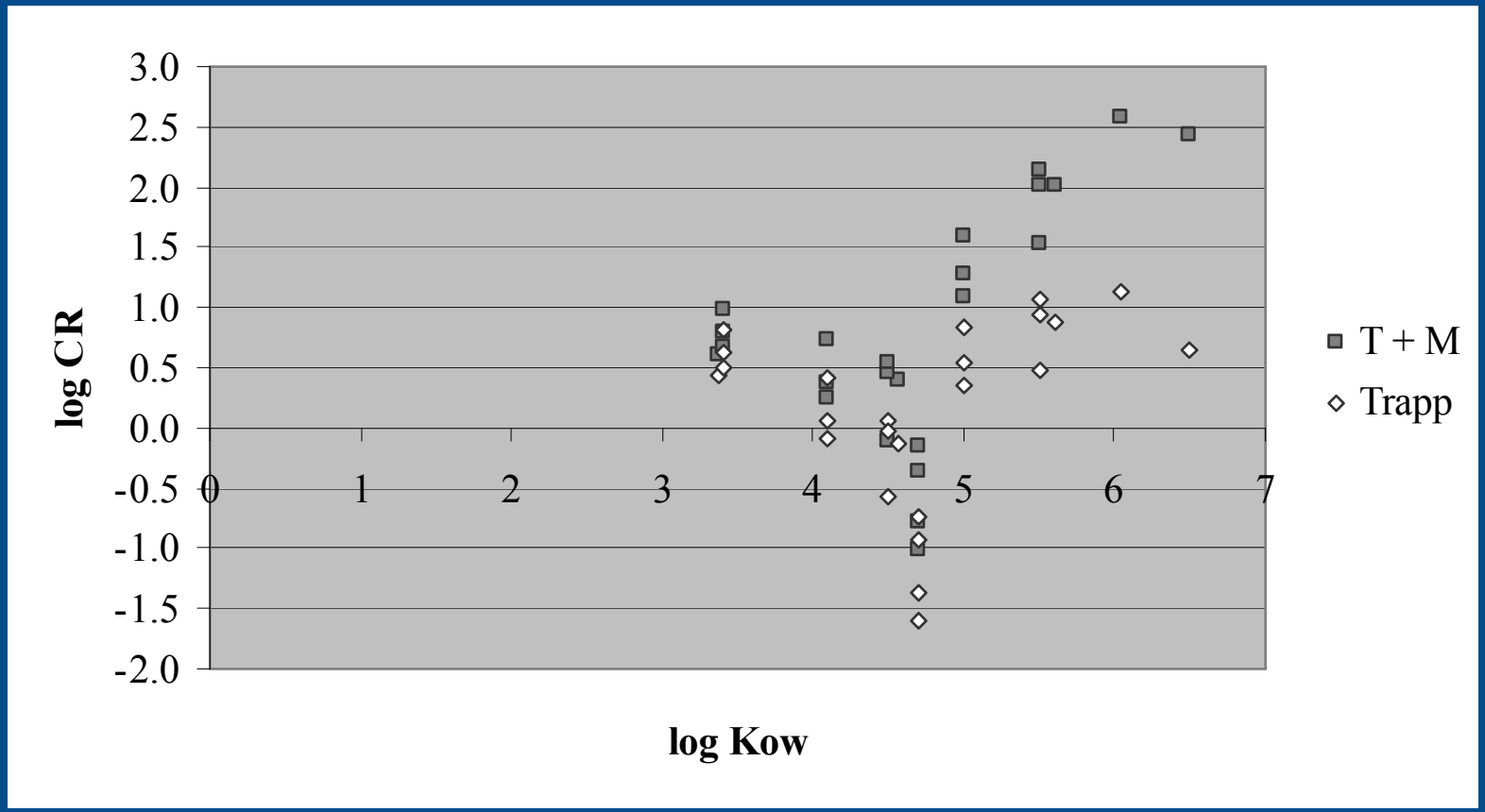
ρ_s is the dry soil bulk density, g cm^{-3}

K_d is the soil – water partition coefficient, cm^3 g^{-1}

Generic models for organic chemicals

- Review by Environment Agency 2006
- Preferred models according to produce categories
  - Leafy vegetables – Ryan *et al*. (1988)
  - Root vegetables – Trapp (2002)
  - Tuber vegetables – Trapp (2007)
  - Tree fruit – Trapp *et al*. (2003)
- No models identified for either herbaceous or shrub fruits

Comparison of generic / specific models



Comparison of predicted versus observed uptake of various chemicals by carrot using Trapp and Matthies (1995) and Trapp (2002). Log CR is the ratio of observed to predicted plant concentrations.

Concluding thoughts

- There are large uncertainties in modelling this pathway
- The only truism in modelling is that *a model is always wrong*
- So why bother?
  - Improve our understanding of processes and better targets resources
  - Measurements of exposure highly variable and often challenging and costly to collect
  - Allows us to “predict” the future (you can’t always measure!)
- Should this pathway be more routinely assessed on a site-specific basis?

Contamination is an emotive issue

EVENING CHRONICLE, Thursday, May 25, 2000 LOCAL NEWS www.northeastonline.co.uk www.evening-chronicle.co.uk 3 5

Study reveals huge contamination levels in waste spread from incinerator

Gran's fury at health fears in allotments

By PETER YOUNG and PETER DICKINSON

FURIOUS protesters disrupted a meeting to announce the results of tests into incinerator ash spread at Tyneside allotments.

Grandmother June Wolf showered scientists and council officials with vegetables grown in her allotment and shouted angrily at them.

Mrs Wolf, 74, said: "We do not believe it is safe to eat and they do not know that it is safe to eat but they tell us to eat it."

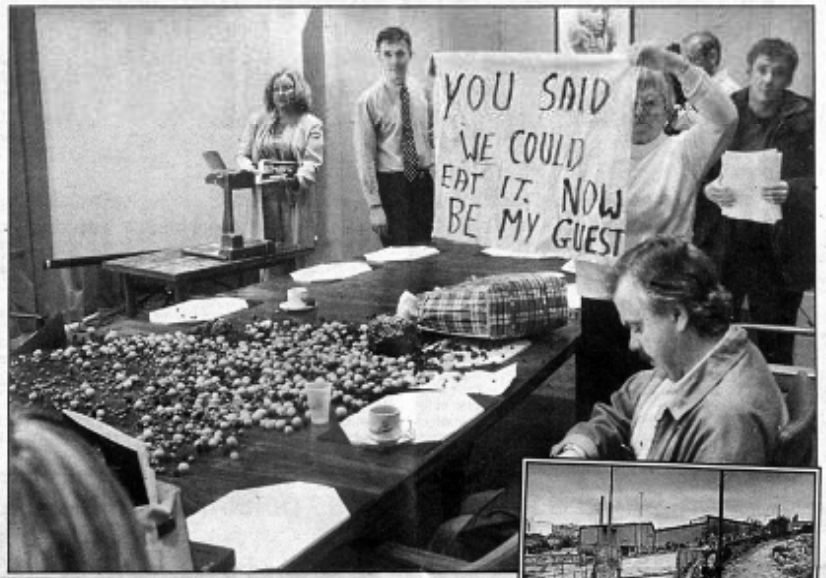
Mrs Wolf, of Fenham said she has regularly fed the vegetables to her grandchildren Alex, six and Tom eight when they visit her home.

The protest came after scientist Dr Tanja Pless-Mulloli of Newcastle University who led testing of samples appeared to change her mind over the safety of eating the vegetables.

Findings

The scientific report recommended the council consider advising allotment gardeners not to eat the vegetables until the results of further tests. But at today's meeting she said: "I think they should eat the vegetables until we have further findings."

Newcastle and North Tyneside Health Authority and Newcastle City Council recommended the vegetables were safe to eat if they were thoroughly washed and peeled after, consulta-



ANGER – June Wolf makes her protest at the meeting revealing the results of health tests on ash from Byker incinerator, inset

worst fears that the Environment Agency