Data for modelling vegetable uptake of trace metals in soil for the VegeSafe program

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A B S T R A C T

Here we detail the soil to vegetable transfer factor (uptake) data and calculation procedures for vegetable trace metal uptake estimation that are presented in Taylor et al. (2021). Firstly, we present the literature review of trace metal uptake data, describing uptake from soil to vegetable produce determined in global experimental studies. After selecting the uptake factors most applicable to the VegeSafe dataset, using similar soil trace metal concentrations and studies that consider only the edible parts of plants, we applied these uptake factors to VegeSafe soils. Using this approach, we were able to estimate trace metal concentrations in home grown produce across the 3,609 homes included in our VegeSafe study. Using Australian and global food standards, we calculated the soil trace metal concentrations that would potentially result in exceedance of Australian and global food safety criteria. Our process followed the method detailed in the Australian soil guidelines (NEPM, 2013). Also presented are the numbers of individual samples and vegetable gardens that are likely to exceed food safety criteria in the three largest cities of Australia: Sydney, Melbourne and Brisbane. Individual household vegetable garden trace metal uptake data were aggregated across standardised geographic areas (Statistical Area Level 3) as established by the Australian Bureau of Statistics to

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visualise the geospatial distribution of potential trace metal risk from home produce.
These modelled data provide the basis for prioritising locations, trace metals and soils for future empirically-based studies of trace metal contamination in home-grown produce.

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Specifications Table

| Subject                        | Environmental Science |
|--------------------------------|-----------------------|
| Specific subject area          | Soil trace metal contamination and health risk of consuming home-grown vegetables in urban environments. |
| Type of data                   | Table                 |
|                                | Graph                 |
|                                | Excel spreadsheet     |
| How data were acquired         | Portable X-ray fluorescence (pXRF) Olympus Delta Pro, 40 kV Rh anode tube for trace metal concentration data. |
|                                | Literature review for uptake factor data. |
|                                | Golden Software Grapher 14.4.420 to make Fig. 1 |
|                                | ESRI ArcGIS 10.15 to make Fig. 2. |
| Data format                    | Raw trace metal data for vegetable garden soils (Supplementary Table 1). |
|                                | Raw literature review for uptake factors. |
|                                | Summarised uptake factor data. |
|                                | Summarised food safety criteria. |
|                                | Analysed data on potential exceedance of food safety criteria. |
| Parameters for data collection | All trace metal data are available on www.mapmyenvironment.com. |
| Description of data collection | Samples were supplied voluntarily by the Australian public as part of Macquarie University’s citizen science Vegesafe program (https://research.science.mq.edu.au/vegesafe/). All samples supplied that were accompanied by a consent form [1] were accepted for analysis. |
|                                | Samples were analysed for the following soil trace metal and metalloid concentrations (hereafter ‘trace metals’): arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn). |
| Data source location           | Institution: Macquarie University, Sydney, Australia |
|                                | City/Town/Region: Australia-wide |
|                                | Country: Australia |
|                                | Individual data points may be viewed at www.mapmyenvironment.com |
| Data accessibility             | Trace metal data for vegetable gardens from Australian homes are provided in Supplementary Table 1. Soil trace metal concentrations are listed using the ABS Statistical Area Level 3 (SA3) boundaries [2]. |
|                                | Repository name: www.mapmyenvironment.com |
|                                | Direct URL to data: www.mapmyenvironment.com |
|                                | Instructions for accessing these data: |
|                                | On homepage, select ‘view global map’ |
|                                | Zoom-in or click on Australia ‘Oceania’ on the map |
|                                | On right-hand menu select ‘soil’ |
|                                | On right-hand menu select contaminant of interest (eg. lead). |
|                                | Zoom/move map to desired location or click on a city of interest |
|                                | Individual sample locations, double jittered within a 150 m radius, will be visible once zoomed in. |

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Value of the Data

- The modelling and analysis undertaken provides an estimation of the concentration of trace metal (and metalloids, hereafter ‘trace metal’) contaminants in home-grown food and how this compares to Australian and World Health Organization food standards. This approach enables the VegeSafe program to respond to questions from citizen scientists who have sent their soil for analysis and who desire to ascertain if their home-grown produce is safe to eat based upon their trace metal soil contaminant levels.
- These data enable home gardeners to understand what levels of soil contamination are likely to cause exceedance of food safety criteria. The data are also useful for environmental planning authorities to understand what contaminants are most likely to pose a risk to food safety in urban settings. In addition, the data allow assessment of whether current Australian soil guidelines remain adequately protective in terms of food safety considerations.
- These data are useful as a preliminary basis with which to inform future studies focussed on verifying actual versus modelled levels of contamination in urban home-grown vegetables. These data provide insight as to what vegetable types should be prioritised and what soil metal concentrations should be targeted in food-safety testing.

1. Data Description

Trace metal data for vegetable gardens from Australian homes are provided in Supplementary Table 1. Soil trace metal concentrations are listed using the ABS Statistical Area Level 3 (SA3) boundaries [2].

Uptake factors for trace metals migrating from soil to the edible parts of plants (leafy vegetables: lettuce, spinach, collard; root vegetables: carrot, radish, beetroot, turnip, parsnip, potato; fruiting vegetables: eggplant, tomato, cucumber, capsicum (pepper), pumpkin; beans; brassicas: cauliflower, broccoli, cabbage, amaranth; herbs: spring onion, berries and tree fruit: oranges, apples, pear, plum) were extracted from literature and are listed in Table 1. Most uptake factors are listed per dry weight. Therefore, moisture content values have also been listed in Table 1 to allow conversion to fresh weight.

Australian and global food standards are listed in Table 1 for all assessed produce types where available. The soil trace metal concentration below which food standards would be met was estimated and also listed in Table 1. These concentration thresholds were calculated using soil to vegetable uptake factors and conversions to fresh weight, as detailed in the method below.

Table 2 presents the percentage of total vegetable garden samples and homes with mean vegetable garden soil Pb, Cd and As concentrations likely to exceed Australian Government [3] and WHO/FAO Codex Alimentarius Commission [4] global food standards. This is based on uptake of contaminants from soil to edible produce, as presented in Table 1. Potential exceedances were calculated using the geometric mean soil concentration required to exceed the respective food standard across vegetables or fruit for which data were available. The criteria for As used here are typically only used for rice but provide a comparison useful to determine food safety [5,6].

Fig. 1 (source: Taylor et al. [1]) summarises the data for estimated trace metal concentrations in food, predicted from the VegeSafe program vegetable garden soil concentration data (Supplementary Table 1). Data are presented as boxplots, with vegetables grouped into categories: leafy vegetables (lettuce, spinach), root vegetables (carrot, beetroot, turnip, parsnip,
Table 1
Literature review and calculations for vegetable (or fruit) uptake of trace metals from soil. Data for edible parts of vegetables (or fruit) were used. Raw uptake factors, moisture content conversions and calculated trace metal produce concentrations in different garden produce with regard to food standards are detailed below.

1. Shaded blue, literature values for uptake factor values are listed. Some are based on fresh weight of produce (in italics), all others are based on dry weight of produce.
2. Shaded green, all uptake factors are converted to fresh weight (where required), using literature moisture content values.
3. Shaded yellow, Australian and international food standards are listed and soil trace metal concentrations at which that food standard would likely be exceeded is calculated, using literature sourced trace metal uptake factors.

| Leafy Vegetables | Root vegetables | Onions | Berries | Tree fruit | Data source and notes |
|-----------------|-----------------|--------|---------|-----------|-----------------------|
| lettuce         | spinach         | carrot | radish  | potato    |                       |
| Arsenic         | soil to produce uptake factor (mg/kg dry weight/ mg/kg soil) | 0.001  | 0.001   |           | 0.00019 | Cheng et al. [7]  |
| Cadmium         | soil to produce uptake factor (mg/kg dry weight/ mg/kg soil) | 0.000213 | 0.700  | 0.190     | Jolly et al. [8]      |
| Chromium        | soil to produce uptake factor (mg/kg dry weight/ mg/kg soil) | 0.000296 | 0.010  | 0.030      | Jolly et al. [8]      |
| Copper          | soil to produce uptake factor (mg/kg dry weight/ mg/kg soil) |                    |        | 0.033      | Jolly et al. [8]      |
| Manganese       | soil to produce uptake factor (mg/kg dry weight/ mg/kg soil) | 2.00          | 3.490  | 0.106      | Odai et al. [11]      |
| Nickel          | soil to produce uptake factor (mg/kg dry weight/ mg/kg soil) | 0.080        | 0.110  | 0.037      | Jolly et al. [8]      |

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### Table 1 (continued)

| Lead  | soil to produce uptake factor (mg/kg dry weight/ mg/kg soil) | data source and notes |
|-------|---------------------------------------------------------------|-----------------------|
| Leafy Vegetables | Root vegetables | Onions | Berries | Tree fruit | Data source and notes |
| lettuce | spinach | carrot | beetroot | turnip/ parsnip/ swede | radish | potato | onion, leek, spring onion | berries | apple/ pear/ plum | orange |
| 0.000034 'green vegetables' | 0.000086 'root vegetables' | 0.000049 | 0.000053 | 0.000037 'tree fruit' | Cheng et al. [7] |
| 0.002 | 0.008 | 0.003 | 0.005 | 0.034 | Entwistle et al. [12], used in calculations where uptake factors were given for a specific vegetable. |
| Range 0.02-14.3 across mixed vegetables | 0.137 | 0.00050 | 0.00017 | 0.203 | Intawongse [9] |
| 0.00255 | 0.00124 | 0.00012 | 0.0007 | 0.000017 | Jolly et al. [8] |
| 0.00023 | 0.00046 | 0.00006 | 0.00014 | Intawongse [9] |
| 0.00034 | 0.00009 | 0.000037 | 0.000069 | Odai et al. [11] |
| 0.0013 | 0.000045 | 0.000024 | 0.0000295 | Kachenko and Singh [10] |
| 0.00085 | 0.00068 | 0.0000094 | 0.000055 | Uptake rates as calculated by Entwistle et al. [12] from: |
| Zinc | soil to produce uptake factor (mg/kg dry weight/ mg/kg soil) | 1.390 | 1.430 | 0.200 | 1.340 | 1.480 | 0.463 | 0.263 | 0.023 | Weekes and Knowles [25] |
| Range | 0.01-32.4 across mixed vegetables | 0.040 | | | | | | | | Intawongse [9] |
| Zinc | soil to produce uptake factor (mg/kg dry weight/ mg/kg soil) | 1.390 | 1.430 | 0.200 | 1.340 | 1.480 | 0.463 | 0.263 | 0.023 | Weekes and Knowles [25] |
Table 1 (continued)

| Leafy Vegetables | Root vegetables | Onions | Berries | Tree fruit | Data source and notes |
|------------------|-----------------|--------|---------|-----------|-----------------------|
| lettuce          | spinach         | carrot | beetroot| radish    | potato                | onion, leek, spring onion | berries | apple/ pear/ plum | orange |
| Conversion to fresh weight using moisture content data |
| 0.063            | 0.0888          | 0.104  | NA      | 0.06      | NA                   | 0.124                  | NA       | NA               | NA     |

Australian and FAO/WHO food standards and soil criteria to meet these, calculated using above soil to vegetable uptake factors and conversions to fresh weight

Cadmium
Australian Food standard (mg/kg fresh weight)
0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1
Soil Cd concentration (mg/kg) at which Australian Food standard for Cd is exceeded 3 1 4 2 47
FAO/WHO Food standard (mg/kg fresh weight)
0.2 0.2 0.1 0.1 0.05
Soil Cd concentration (mg/kg) at which FAO/WHO Food standard for Cd is exceeded 6 2 4 2 24

Lead
Australian Food standard (mg/kg fresh weight)
0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1
Soil Pb concentration (mg/kg) at which Australian Food standard for Pb is exceeded 199 49 105 500 81 87 474 123 1538 7143 98
FAO/WHO Food standard (mg/kg fresh weight)
0.3 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1
Soil Pb concentration (mg/kg) at which FAO/WHO Food standard for Pb is exceeded 596 105 500 81 87 474 123 1538 743 98

Arsenic
Australian Food standard (mg/kg fresh weight)
1 1 1 1 1 1 1 1 1 1 1 1
Soil As concentration (mg/kg) at which Australian Food standard for As is exceeded 9615 16667 5167
EU Food standard (mg/kg fresh weight)
0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2
Soil As concentration (mg/kg) at which FAO/WHO Food standard for As is exceeded 1923 3333 1033

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| Fruit   | Vegetables          | Data source and notes |
|---------|---------------------|-----------------------|
| **Arsenic** | Eggplant (brinjal, aubergine) | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.001  | 0.001               | 0.001                 |
| **Cadmium** | tomato              | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.0127 | 0.069               | 0.112                 |
| **Chromium** | cucumber           | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.0192 | 0.008               | 0.087                 |
| **Copper** | cauliflower         | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.0001 | 0.0001              | 0.001                 |
| **Arsenic** | broccoli            | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.001  | 0.001               | 0.001                 |
| **Cadmium** | cabbage             | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.116  | 1.16                | Jolly, et al. 1       |
| **Chromium** | collard             | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.010  | 0.092               | Jolly, et al. 1       |
| **Copper** | amaranth            | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.002  | 0.002               | Jolly, et al. 1       |
| **Manganese** | tomato             | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.001  | 0.001               | Jolly et al. [8]      |
| **Nickel** | cucumber           | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.015  | 0.015               | Jolly et al. [8]      |
| **Lead** | cauliflower         | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.043  | 0.043               | Jolly et al. [8]      |
| **Zinc** | broccoli            | soil to produce uptake factor (mg/kg dry weight / mg/kg soil) |
| 0.014  | 0.014               | Jolly et al. [8]      |

*Note: Uptake rates as calculated by Entwistle et al. [12] from:
• Darmody et al. [13]
• Demirezen and Aksoy [14]
• Gorbunov et al. [15], high Pb soil closest to VegeSafe Pb
• Davies [16]
• Moir and Thornton [19]
• Gzyl [17]
• Pilgrim and Schroeder [21]
• Lim et al. [18]
• Depieri et al. [20]
• Ward and Savage [24]
• Weeks and Knowles [25]*

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### Table 1 (continued)

| Fruiting vegetables | Beans | Brassicas | Data source and notes |
|---------------------|-------|-----------|-----------------------|
| Eggplant (brinjal, suberigne) | tomato | cucumber | capsicum | pumpkin | bean | cauliflower | broccoli | cabbage | collard | amaranth |
| Conversion to fresh weight | | | | | | | | | | | | | |
| 0.0712 | 0.0527 | NA | NA | NA | 0.0947 | 0.0750 | NA | 0.109 | 0.109 | 0.161 |

**Cadmium**

| Australian Food standard (mg/kg fresh weight) | Soil Cd concentration (mg/kg) at which Australian Food standard for Cd is exceeded | FAAO/WHO Food standard (mg/kg fresh weight) | Soil Cd concentration (mg/kg) at which FAO/WHO Food standard for Cd is exceeded |
|-----------------------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 7 | 1 | 0.05 | 0.2 | 3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |

**Lead**

| Australian Food standard (mg/kg fresh weight) | Soil Pb concentration (mg/kg) at which Australian Food standard for Pb is exceeded | FAAO/WHO Food standard (mg/kg fresh weight) | Soil Pb concentration (mg/kg) at which FAO/WHO Food standard for Pb is exceeded |
|-----------------------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 270 | 234 | 235 | 26 | 34 | 346 | 652 | 27273 | 643 | 29 |

**Arsenic**

| Australian Food standard (mg/kg fresh weight) | Soil As concentration (mg/kg) at which Australian Food standard for As is exceeded | EU Food standard (mg/kg fresh weight) | Soil As concentration (mg/kg) at which FAO/WHO Food standard for As is exceeded |
|-----------------------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18055 | 10560 | 13333 | 3106 |
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| 2811 | 1795 | 2112 | 2667 | 621 |

1. Intawongse\(^3\) data for 'high' contaminated soil were used ('medium' for Cr) because trace metal concentrations in this soil most closely reflected Australian residential soil criteria HIL-A\(^3\) as uptake factors decreased with concentration, use of 'low' contaminated soil would over-predict trace metal concentration in vegetables.
2. Values from Kachenko and Singh\(^3\) were not used in calculations as there was insufficient data available to accurately characterise uptake factors from topsoil to specific produce.
3. Lead uptake values from Odai, et al.\(^4\) were not used in calculations as they were based on soils with low Pb concentration and (50 mg/kg) would over-predict uptake in the Australian context.
Table 2
Percentage of total vegetable garden samples and homes with mean vegetable garden soil Pb, Cd and As concentrations likely to exceed Australian Government [3] and FAO/WHO Codex Alimentarius Commission [4] global food standards based on uptake of contaminants from soil to edible produce. These are based on the geometric mean soil concentration needed to exceed the food standard across all vegetables/fruit for which data were available. Criteria used here for As [5,6] are typically only used for rice but provide a comparison useful to determine food safety.

| Participation (number of samples) | Percent of samples or homes likely to exceed Australian food standard | Percent of samples or homes likely to exceed WHO food standard |
|-----------------------------------|-------------------------------------------------|-------------------------------------------------|
| Total number of homes Australia   | Pb 20  Cd 1.8  As 0 | Pb 17  Cd 6.1  As 0 |
| Total homes Sydney area           | Pb 31  Cd 1.7  As 0 | Pb 27  Cd 4.5  As 0 |
| Total homes Melbourne area        | Pb 19  Cd 2.1  As 0 | Pb 17  Cd 6.1  As 0 |
| Total homes Brisbane area         | Pb 19  Cd 2.8  As 0 | Pb 14  Cd 2.8  As 0 |

Fig. 1. Trace metal concentrations in food predicted from the VegeSafe program vegetable garden soil concentration data combined with vegetable uptake factors from soil (Table 1). The median concentration in vegetables is shown as a solid line at the centre of each boxplot, with notches displaying 95% confidence intervals; the body of the boxplot displays the interquartile range (25th and 75th percentile) and boxplot whiskers show the 5th to 95th percentiles. All As values satisfied food standards. Source Taylor et al. [1].

swede, radish, potato), fruiting vegetables (eggplant (also known as aubergine or brinjal), tomato, cucumber, capsicum, pumpkin), brassicas (cauliflower, broccoli, cabbage, collard, amaranth) and tree fruits (orange, apple, pear, plum). Boxplots show data median, 95% confidence intervals from the median; interquartile range (body of boxplot, 25th and 75th percentile) and 5th to 95th percentiles of the dataset (whiskers).

The percent of vegetable gardens from which produce is likely to exceed Australian food standards due to the uptake of Pb from soil by edible plants, for each SA3 statistical area, are displayed in Fig. 2. Australia’s three largest state capital cities, Sydney, Melbourne and Brisbane,
Fig. 2. Percent of vegetable gardens from which produce is likely to exceed Australian food standards due to the uptake of Pb from soil by edible plants is shown for each SA3 statistical area [2]. Centroid points indicate the average Pb concentration for sampled vegetable gardens within each SA3. Panels AC show: (A) map of Greater Sydney local areas, (B) map of Greater Melbourne local areas, (C) map of Greater Brisbane local areas. Adapted from Taylor et al. [1].
have been shown here, as they comprise 68% of all VegeSafe samples and represent ~50% of the national population.

2. Experimental Design, Materials and Methods

A total of 6,777 soil samples were submitted from 2,631 vegetable gardens across Australia. These vegetable garden soils are a subset of the larger VegeSafe dataset, which contained 17,256 soils from 3,609 homes. These were sent via post to Macquarie University by Australian citizen scientists wishing to participate in the VegeSafe program. Full details of packaging and communication with participants are provided in Taylor et al. [1].

Samples were analysed by portable X-ray fluorescence (pXRF) spectrometer (Olympus Delta Pro, 40 kV Rh anode tube) for As, Cd, Cr, Cu, Mn, Ni, Pb and Zn concentration as detailed in Taylor et al. [1].

In order to address the basic food safety concerns posed by the public while retaining scientific quality, we used the standard method as detailed in the National Environmental Protection Measure [36] legislation to estimate vegetable uptake of trace metals. Whilst it would be preferable to collect actual vegetable samples and analyse those for trace metals and to further examine soil chemistry, this was beyond the scope of the citizen science funded program (samples are submitted with a $20 voluntary donation from participants) and not possible across the 2,631 vegetable gardens assessed, comprising 6,777 soil samples. Thus, the next best alternative was to estimate the potential uptake using the NEPM process. The Australian soil guidelines [36] were developed in 1999 in consideration of contemporary literature on plant uptake from soils (Schedule B7, Appendix A1). In order to determine if these Australian Guidelines remain adequately protective in terms of food safety considerations, literature published since these guidelines were reviewed to collate recent data regarding uptake of trace metals by vegetables (Tables 1 and 2).

Trace metal uptake factors from soil to produce were located using search terms: vegetable uptake, transfer factors, metal transfer, metal uptake, soil to plant transfer, growing in contaminated soils, metal contamination in vegetables.

Literature values for uptake of trace metals by different types of fruits and vegetables were collated (Table 1). Literature values for uptake factors varied up to an order of magnitude between studies, dependant on metal concentrations inter alia. In order to avoid over-estimation of trace metals in vegetables, the factors used were selected from published studies where soil metal concentrations were similar to those in VegeSafe program samples, as noted throughout Table 1. Food produce uptake values derived using soil metal concentrations that were significantly lower than typical VegeSafe values were discounted, as these would overestimate soil to food produce concentration values. Uptake factors were considered only for edible parts of the plant.

Most participants supplied two or more samples from their vegetable garden soil. Trace metal concentrations from vegetable garden soils only were averaged to give a single vegetable garden concentration for each property before data analyses were performed. Concentrations for individual properties may be viewed on www.mapmyenvironment.com.

Uptake factors for trace metal movement from soil to plants were used to estimate concentrations in fresh garden produce, which were compared to Australian [3] and WHO/FAO food standards [4]. Trace metal food standards were available for Pb and Cd for fruit and vegetables. Arsenic food standards were only available for rice [5,6], however these were also used to infer ‘acceptable’ As concentrations in fruit and vegetables. Where literature uptake values listed dry weight, values were converted to fresh weight using published moisture content data (Table 1).

Other factors including trace metal concentrations, pH, organic matter content and interaction with other metals [37,38] influence uptake. However, other variables were not taken into account due to data availability. Notwithstanding the potential relevance of other variables, the uptake of soil trace metals to different produce types was assessed using the method previously
applied in development of the Australian Pb soil guidelines [36]. The modelled results are summarised in Fig. 1.

For each produce type, we calculated the geometric mean of all applicable uptake factors from contemporary literature sources (Table 1). This was applied to soil vegetable garden trace metal concentrations measured in each garden to estimate concentration in food if that produce type were grown. These results are summarised in Fig. 1.

Using this process, we were able to estimate, based on Australian and global food standards (Table 1), the upper maximum soil trace element levels suitable for domestic vegetable garden food production.

Ethics Statement

Approval for the VegeSafe project was obtained in 2013 from Macquarie University with concurrence from the National Health and Medical Research Council. Approval was reaffirmed on 27 September 2019 by Macquarie University’s Office of Research Ethics and Integrity. Participants submitted consent forms [1] along with their samples.

Individual data displayed on www.mapmyenvironment.com are protected using web and data platforms that are hosted on a firewalled and dedicated server at Indiana University-Purdue University, USA, using a ShinyApp. Data visualisations are “double-jittered” to ensure a participant’s address is not specifically identified. True location data are initially jittered 150 m in a random direction before uploading to the IUPUI server. That new location is again jittered by 150 m in a random direction before every web visualisation. This ensures that no specific home location is identifiable through iterative recasting of the map.

CRediT Author Statement

Cynthia Faye Isley: Conceptualisation, methodology, data curation, formal analysis, investigation, writing; Xiaochi Liu: data curation, formal analysis; Kara L. Fry data curation, formal analysis, review and editing, Max M. Gillings: formal analysis; Mark Patrick Taylor: Investigation, project administration, review and editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

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Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2021.107151.

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