

## **Phase Two of the Contaminants in Fertilisers Project and the Role of FIFA and its members**

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### **Executive Summary**

In 2002 a public outcry arose over the use of contaminated industrial wastes in some fertilisers and their application to agricultural soils. Federal and State governments responded by stating that guidelines would be established to prevent this re-occurring. The Fertiliser Working Group was established and given the task of ensuring this occurred. A three phase project was developed and CSIRO employed to undertake the first phase – a Scoping Study. The Scoping Study outlined a framework for the second and third phases. Following a tender process, CSIRO was employed to conduct Phase Two. This presentation will outline the methods to be used in conducting Phase Two and how FIFA and its members can facilitate this. The interaction between the project team and FIFA and its members will be vital to the success of Phase Two of the Contaminants in Fertiliser Project.

### **Scope of Phase Two**

Before discussing how we will undertake the project it is essential to clearly define the parameters within which Phase Two of the project will be conducted.

1. Only chemical fertilisers will be examined (i.e. organic fertilisers such as composts and alternative wastes will not be examined).
2. The following contaminants or sources of contaminants will be investigated:
  - Inorganics: Essential elements, heavy metals, metalloids, radionuclides, rare earth elements, and anionic elements. Specifically As, B, Cd, Cr, Cu, F, Hg, Ni, Pb, Se, and Zn;
  - Organics: Pesticides, persistent organic pollutants (e.g. PCBs, dioxins and furans, PAHs), flocculants, coagulants, surfactants, pharmaceutical and personal care products and known endocrine disruptors. Where appropriate (i.e. chemicals with the same mode of action) the toxic equivalent approach will be used; and
  - Sources of contaminants: raw materials of mineral fertilisers, mining and smelting by-products, energy wastes, and other industrial wastes.
3. The following adverse effects will be considered:
  - Increased release or bioavailability of contaminants leading to negative effects on soil ecosystems, aquatic ecosystems or plants, in the short or long term;
  - Accumulation or concentration in the food chain producing unacceptable contaminant levels from a trade or human health perspective;
  - Potential for contaminant mobilisation and off-site migration at concentrations sufficient to cause negative impacts on off-site ecosystems; and
  - Toxic to domestic animals, livestock and wildlife.

4. The three agricultural systems that will be considered are:
  - Horticulture – includes vegetables and flowers, and “recreational horticulture” (e.g. turf farms, golf courses and sports grounds);
  - Sugarcane and rotational crops; and
  - Dairy production.
5. All assessments will be based on protecting ecosystems from adverse effects of contaminants for 100 years.
6. The ‘ingredient approach’ will be used to determine which chemicals or materials should not be permitted in fertilisers. (Effectively the ‘ingredients approach’ controls fertilizer quality through prohibiting the use of substances or ingredients, rather than contaminant concentrations or loadings to soil.)
7. A combination of a mass concentration approach and a hazard assessment methodology will be used to determine which chemicals or ingredients pose an acceptable or high potential hazard to terrestrial and aquatic ecosystems. Those chemicals that pose a low or acceptable hazard will have guideline values derived as part of Phase 2. Those chemicals that pose a high hazard will require further analysis in Phase 3.

#### **Methods to be used in Phase Two**

There are four main components in the methods to be used in Phase Two. These are: (1) sourcing and collation of data; (2) determining the list of chemicals, substances and materials that should not be permitted in fertilisers; (3) preliminary screening; and (4) hazard assessment. Components 3 and 4 will be conducted on those chemicals that are permitted in fertilisers. How we intend to conduct each component is set out below.

#### ***Sourcing and collation of data***

Phase Two is a desktop study that will not generate any new scientific data; rather it will rely on existing data in the scientific and technical literature and non-public sources. As such a vital component to the success of the project will be obtaining the necessary data. This will be undertaken by:

- CSIRO library and project team staff conducting searches of relevant databases (Agricola, CAB, ISI, Google Scholar etc.);
- Project team staff searching appropriate scientific journals that are not covered by the above databases and search engines;
- Directly contacting known experts in the field (from academia, regulatory authorities and industry) for information, unpublished reports etc; and
- *Liaising with FIFA and member organisations of FIFA.*

The principle focus of all data searches will be for data relevant to Australia. However, where such data is not available, data from international sources will be sought using the above methods.

Data will only be sought for those chemicals, substances and materials (CSMs) that are specified in the “Scope of Phase Two” and on page 10 of the Request For Tender (RFT) document. The key factor that will limit how many CSMs can be assessed will be the availability of appropriate data.

The following will be collected:

- data on current levels on CSMs in fertilisers and soil additives from the published literature, *industry organisations (e.g. FIFRA), fertilizer manufacturers and importers*;
- information on recommended rates and frequencies of application from *industry organisations (e.g. FIFRA), fertilizer manufacturers and importers*;
- international information relating to this issue by conducting computer searches of relevant databases (Agricola, CAB, ISI, etc.) to place the Australian information in a global context;
- data for both raw materials and for finished products from *industry organisations (e.g. FIFRA), fertilizer manufacturers and importers*;
- background concentrations of the contaminants of concern in Australian agricultural soils from the literature;
- physicochemical, environmental fate and toxicity data for the contaminants of concern from databases (e.g. ECOTOX and Australasian Ecotoxicology Database) and the scientific literature; and
- soil, water and food quality guidelines of regional, state and national regulatory authorities will be obtained by conducting computer searches and contacts of the team members.

By collating the above information we will identify existing information gaps for the contaminants of concern, and suggest a process to address these.

#### ***Determining the list of chemicals that should not be permitted in fertilisers***

The first step is to develop a comprehensive list of potentially beneficial effects that any material could have on plants, soil chemistry, structure or physical properties or in the efficacy of the fertilisers. Those CSMs that do not have confirmable positive effects on at least one of the above would be prohibited from use in the manufacture or formulation of fertilisers. The CSMs that have beneficial properties will proceed to the Preliminary Screening. The CSMs for which there is information, from the literature, that indicates that they do not exert any beneficial effects will be specifically mentioned in the list of chemicals not permitted in fertilisers. It is quite possible, however, that for many CSMs that no information on their effects on soil or plants will be available. In such cases, we recommend that the precautionary principle be applied and these CSMs would be added to the list not permitted in fertilisers. For groups of chemicals (e.g. pesticides) or sources of contaminants it will not be possible to name all CSMs for which there is no information. Therefore we suggest that the list of CSMs not permitted in fertilisers include those specifically stated but also all CSMs that are not specifically mentioned in the list of permitted CSMs. In other words, if a CSM is not in the list of permitted substances it should be assumed to be part of the list of prohibited CSMs.

It should however, be possible for proponents to submit new data and mount a case for a CSM to be removed from the prohibited list (i.e. they have to prove that the CSM has a beneficial effect and no adverse effects). However, we suggest that the reallocation of a CSM should only be done if in addition, the proponents provide sufficient information to permit a maximum permissible guideline value to be derived in accordance with the accepted methodology.

One issue that remains unresolved is how you monitor and enforce the list of prohibited CSMs. Policy decisions will need to be made by the FWG and IRWG on whether the prohibition is absolute (i.e. any detection is an exceedance) or whether very small concentrations are permissible. It will also be necessary to require analytical techniques be used in the monitoring programs that obtain a certain

minimum practical quantitation limit or alternatively analytical methods could be prescribed.

### ***Preliminary Screening***

The key data that are required to undertake this are a comprehensive database of the concentrations of chemicals in fertilisers used in Australia and background concentration data for each of these chemicals in Australian soils. Published data and that held by regulatory authorities, *fertilizer manufacturers and Fertilizer Industry representative organisations* will be sought for all fertilisers sold in Australia. Preference will always be given to using the most recent reliable, high quality data.

Background concentration data will be sort for Australian soils from the literature. If none are available then appropriate international data will be used. For metals the model of Hamon et al (2004) will be used to estimate the background concentrations. For all man made organic chemicals the background concentration will be assumed to be zero. However, whether this should also apply to persistent organic pollutants such as DDT needs to be carefully considered, as these chemicals are now found ubiquitously on Earth. For naturally occurring organic chemicals it would be best if background concentrations could be obtained, however if this is not possible a background concentration of zero will be assumed.

Conservative assumptions and conservative decisions will be made in conducting the preliminary screening. Thus, the highest reliable measured concentration of a CSM in an Australian fertilizer and the lowest background concentration will be used. The preliminary screening will be conducted using the hazard quotient method (Urban and Cook, 1986). Hazard quotients (HQ) will be calculated using the following formula:

$$\text{HQ} = \frac{\text{highest measured fertilizer concentration}}{\text{lowest background value or estimate of background}} \quad (1)$$

A HQ value greater than or equal to one indicates that the CSM concentration in the fertilizer is greater than the background concentration and therefore it could accumulate over time to cause elevated soil concentrations. Such a scenario would be classed as posing a 'high' hazard. A HQ value of less than one means that the CSM concentration in the fertilizer is less than the background concentration and given that the fertilizer is never applied on a 1:1 basis to soil, then there is no chance that the concentration of the CSM in soil will increase over time. Such a scenario would be classed as posing a 'low' hazard.

Those contaminants that receive a 'high hazard' classification will then be subject to the hazard assessment (see next section). Those contaminants that receive a 'low' hazard classification will not proceed to the hazard assessment; rather guideline limits will be derived. The guideline limit for CSMs in fertilisers that have a 'low' hazard should equal the estimate of background concentration used in equation 1. However in order to be consistent with the "no more than necessary" principle it is recommended that fertilizer manufacturers not use ingredients that contain any higher contaminant concentration than is necessary.

For CSMs which lack the data required for equation 1 a preliminary screening will not be possible. A list of the CSMs for which the preliminary screening can not be conducted along with the reason (i.e. the data gaps) for this will be included in the final report. Given that a guideline value can not be derived it is recommended that these chemicals are included in the list of CSMs not permitted in fertilisers until such time that a maximum guideline value can be determined.

### **Hazard Assessment**

For the hazard assessment, the hazard quotient method (Urban and Cook, 1986) will again be used with some slight modifications. Hazard quotients will be calculated using the following formula:

$$\text{HQ} = \frac{\text{highest estimated environmental concentration}}{\text{lowest threshold value}} \quad (2)$$

where the lowest threshold value is the lowest toxicity value or the lowest environmental, food or human health guideline or standard (e.g. the Australian and NZ water quality guidelines [ANZECC and ARMCANZ, 2000], FSANZ guidelines [FSANZ, 2005], USEPA ECOSL values [<http://www.epa.gov/ecotox/ecossl/> ] ) for that contaminant. Given the two parameters used in Equation 2, the HQ values are conservative (i.e. tend to favour the environment and human health).

There are two key differences between the hazard assessment conducted here and that conducted in the preliminary screening that improve the environmental realism of the assessment. First, estimates of the concentration of CSMs in soil (taking into account application rates etc) are used rather than simply the concentration in the fertilizer itself. Second, the estimated soil concentrations are compared to those concentrations that are known to cause toxic effects or to soil, water and human health guidelines rather than simply background concentrations.

Depending on the chemical, there may be the potential for off-site migration of some CSMs in fertilisers and therefore the hazard posed to both terrestrial and aquatic ecosystems will need to be assessed.

The hazard will be classed as 'low' if the HQ is  $\leq 0.1$ , 'moderate' when between 0.1 and 0.5 and 'high' when the HQ  $> 0.5$ . The highest hazard classification that a contaminant receives from both the aquatic and terrestrial hazard assessments will become the overall assessment. Chemicals that receive a high hazard classification will require further investigation, in the form of a probabilistic risk assessment and have their guideline limit derived using critical load models (i.e. Phase Three of the consultancy).

Hazard assessments are usually calculated using a series of environmental scenarios, of decreasing environmental conservatism and increasing environmental realism. These scenarios are well established for the application of pesticides to both aquatic and terrestrial ecosystems but are not established for the application of fertilisers.

Based on pesticide experience, the following scenarios for the application of fertilisers are proposed, but may change subsequently. A reasonably conservative scenario would be for a one hectare block of land to receive the maximum recommended application rate of fertilizer at the maximum recommended frequency for 100 years (the maximum period of time that the soils are to be protected for) and assuming that there is no loss of any of the chemicals added with the fertilisers. An equivalently conservative aquatic scenario would be for a one hectare pond that is homogeneously mixed to 15 cm deep to receive all of the fertilizer added in the terrestrial scenario. Contaminants that are determined to pose a low hazard under these scenarios are likely to be very safe. However, there are others contaminants that may pose a high hazard – for such chemicals the distribution coefficient of the contaminant will be used to generate more environmentally realistic concentrations for use in the hazard assessment. Only those that continue to pose a high hazard will

be subject to probabilistic risk assessment and critical load modeling in Phase Three of the project.

The depth of incorporation of the fertilizer in the soil will vary according to agricultural practice and this will modify the estimated environmental concentration and HQ values. The HQ analysis will be conducted for horticulture, sugar and other rotation crops, and dairy agricultural systems. Given the variation in the composition of fertilisers the HQ analysis will be conducted for each of the major types of fertilizer (e.g. phosphatic; trace element; and soil amendments).

One of the limitations that will be encountered is that the vast majority of toxicity data only measure the effects of direct exposure to chemicals absorbed from the ambient environment. The majority do not address the issue of real world exposures where organisms are exposed to the toxicants from both the ambient environment and from the food they consume. This is only a limitation for those chemicals that tend to accumulate in animal and plant tissue (i.e. chemicals with high bioconcentration (BCF), bioaccumulation (BAF) or biomagnification (BMF) factors or high octanol-water partition coefficients (Kow)). This limitation of the toxicity data is often carried through to the various guidelines and standards which are derived from the toxicity data. Thus, if the threshold data used to determine the HQ values does not account for accumulation then the hazard assessment will also fail to consider this. It is recommended that if there is not appropriate threshold data (that accounts for accumulation) all chemicals with a moderate to high potential to accumulate (BCF, BAF, BMF or  $Kow \geq 1000$ ) should automatically proceed to Phase Three of the project.

The purpose of the hazard assessment is to identify those chemicals that pose a potential hazard to the environment. The hazard assessment is conservative, thus only chemicals that pose a "high hazard" would warrant the development of guideline limits from first principles (to be conducted during Phase III of the project). For those chemicals that pose a "low" or "acceptable hazard" two guideline values will be derived - the guideline limit and an upper limit for contaminants in fertilisers. The guideline limit would effectively become the current maximum level of contamination in fertilisers – such an approach is consistent with the "no more than necessary" principle. The upper limit would be equal to the concentration of the chemical that corresponds to a HQ value of 0.5. The purpose of having the two values (i.e. the guideline limit and upper limit) is that it may be necessary to change the source of a component of a fertilizer that may have a higher concentration of the chemical than is currently used. In such a case industry would need to determine the concentration of the contaminant and compare that to the upper limit. Provided the measured concentration in the new source was below the upper limit then it could be approved by the appropriate regulatory body. If, however, the measured concentration in the fertilizer exceeded the upper limit then a guideline limit would have to be derived using critical load modeling and the measured concentration compared to that.

For contaminants/ingredients which lack the data required for equation 2 a hazard assessment will not be possible. A list of the contaminants of concern for which the hazard assessment can not be conducted along with the reason (i.e. the data gaps) for this, will be included in the final report.

By the end of the project a list of prohibited contaminants/ingredients in fertilisers, a list of contaminants/ingredients which could not be assessed and the reasons why, a list of guideline values for contaminants/ingredients and a list of contaminants/ingredients that require further analysis (critical load modeling in Phase Three) will have been generated.

### **Timetable for the project**

The timetable for deliverables (including workshops, progress reports, draft and final reports) for Phase Two of the Contaminants in Fertilisers project is set out in Table 1. The project is set to commence on 1 September 2007 and submission date for the final report is 1 September 2008.

### **Role of FIFA and its members**

The Fertiliser Industry Federation of Australia (FIFA), the Australian Fertiliser Spreader Association (AFSA), fertiliser manufacturers, importers and distributors all have a vital role to play in success of Phase Two of the Contaminants in Fertiliser project. This is in providing the project team with information and providing feedback during workshops and on reports.

### **Information required**

We are seeking from *FIFA and its members*:

- comprehensive data on the concentrations of all measured chemicals in all chemical fertilisers used in Australia;
- recommended application rates (mass/ha and frequency of application) for all chemical fertilisers used in Australia;
- typical application rates (mass/ha and frequency of application) for all chemical fertilisers used in Australia;

### **Feedback sought**

Stakeholders including FIFA and its members will be provided with a number of opportunities to have provide input or feedback into Phase Two. The specific events where this can occur are:

- Preliminary Report and 1<sup>st</sup> workshop;
- Discussion Paper; and
- 2<sup>nd</sup> Workshop.

Thus the interaction between FIFA and its members and the project team will be crucial to the success of Phase Two of the Contaminants in Fertilisers project.

Table 1. Workplan for Phase 2 of the project along with the key outputs and who is responsible for the outputs.

Date	Tasks	Outputs
Sept 2007	Inception Meeting	Minutes
Sept – Nov 2007	Finalise methodology; establish QAQC forms and procedures; collate data*; commence preliminary screening and hazard assessment	
	Write 1 <sup>st</sup> Progress Report	1 <sup>st</sup> Progress Report
	Write Preliminary Report	Preliminary Report
	Submit Preliminary Report to FWG and IRWG	
	1 <sup>st</sup> Workshop with FWG & IRWG and <b>stakeholders</b> to discuss the Preliminary Report.	Workshop and minutes
Dec 2007 – Jun 2008	Continue data collation* Continue preliminary screening and hazard assessment	
	Write 4, 6 and 8 month Progress Reports	Progress Reports
	Write Discussion Paper	Discussion Paper
Middle of June 2008	Supply FWG and IRWG with Discussion Paper and place it on website for <b>stakeholders</b>	Discussion Paper
End of June 2008	Organise 2 <sup>nd</sup> Workshop with FWG & IRWG and <b>stakeholders</b>	Workshop, workshop material and report
	Write 10 month Progress Report	Progress Report
July 2008	Prepare Draft Report taking account of issues identified during 2 <sup>nd</sup> workshop & feedback	Draft Report
Start of Aug 2008	Submit Draft Report to FWG & IRWG for comment and internal (CSIRO) review	Feedback from FWG and IRWG
End of Aug 2008	Take on board comments received and write Final Report and submit	Final Report

\* This will involve team members visiting Brisbane, Sydney, Melbourne, Perth and Canberra each for 2 - 3 days.

## References

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