Ecological Soil Screening Levels for Manganese

Interim Final

OSWER Directive 9285.7-71

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

April 2007
# TABLE OF CONTENTS

1.0 INTRODUCTION ................................................................. 1

2.0 SUMMARY OF ECO-SSLs FOR MANGANESE ................................. 2

3.0 ECO-SSL FOR TERRESTRIAL PLANTS ................................... 4

4.0 ECO-SSL FOR SOIL INVERTEBRATES .................................... 4

5.0 ECO-SSL FOR AVIAN WILDLIFE ........................................ 7
  5.1 Avian TRV .................................................................... 7
  5.2 Estimation of Dose and Calculation of the Eco-SSL ................. 10

6.0 ECO-SSL FOR MAMMALIAN WILDLIFE .................................. 10
  6.1 Mammalian TRV .......................................................... 10
  6.2 Estimation of Dose and Calculation of the Eco-SSL ................. 13

7.0 REFERENCES ................................................................. 15
  7.1 General Manganese References .......................................... 15
  7.2 References for Plants and Soil Invertebrates ......................... 16
  7.3 References Rejected for Use in Deriving Plant and Soil Invertebrate Eco-SSLs ............................................................... 16
  7.4 References Used in Deriving Wildlife TRVs ........................... 35
  7.5 References Rejected for Use in Derivation of Wildlife TRV ........ 40
LIST OF TABLES

Table 2.1  Manganese Eco-SSLs (mg/kg dry weight in soil) ................................. 3
Table 3.1  Plant Toxicity Data - Manganese .................................................. 5
Table 4.1  Invertebrate Toxicity Data - Manganese ........................................ 6
Table 5.1  Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV) - Manganese ............................................................. 8
Table 5.2  Calculation of the Avian Eco-SSLs for Manganese .............................. 10
Table 6.1  Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV) - Manganese .......................................................... 11
Table 6.2  Calculation of the Mammalian Eco-SSLs for Manganese ..................... 13

LIST OF FIGURES

Figure 2.1  Typical Background Concentrations of Manganese in U.S. Soils ............ 2
Figure 5.1  Avian TRV Derivation for Manganese ........................................... 9
Figure 6.1  Mammalian TRV Derivation for Manganese ..................................... 14

LIST OF APPENDICES

Appendix 5-1  Avian Toxicity Data Extracted and Reviewed for Wildlife Toxicity Reference Value (TRV) - Manganese
Appendix 6-1  Mammalian Toxicity Data Extracted and Reviewed for Wildlife Toxicity Reference Value (TRV) - Manganese

ii
1.0 INTRODUCTION

Ecological Soil Screening Levels (Eco-SSLs) are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with and/or consume biota that live in or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: plants, soil invertebrates, birds, and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. Eco-SSLs are derived to be protective of the conservative end of the exposure and effects species distribution, and are intended to be applied at the screening stage of an ecological risk assessment. These screening levels should be used to identify the contaminants of potential concern (COPCs) that require further evaluation in the site-specific baseline ecological risk assessment that is completed according to specific guidance (U.S. EPA, 1997, 1998, and 1999). The Eco-SSLs are not designed to be used as cleanup levels and the United States (U.S.) Environmental Protection Agency (EPA) emphasizes that it would be inappropriate to adopt or modify the intended use of these Eco-SSLs as national cleanup standards.

The detailed procedures used to derive Eco-SSL values are described in separate documentation (U.S. EPA, 2003, 2005). The derivation procedures represent the collaborative effort of a multi-stakeholder group consisting of federal, state, consulting, industry, and academic participants led by what is now the U.S. EPA Office of Solid Waste and Emergency Response (OSWER).

This document provides the Eco-SSL values for manganese and the documentation for their derivation. This document provides guidance and is designed to communicate national policy on identifying manganese concentrations in soil that may present an unacceptable ecological risk to terrestrial receptors. The document does not, however, substitute for EPA's statutes or regulations, nor is it a regulation itself. Thus, it does not impose legally-binding requirements on EPA, states, or the regulated community, and may not apply to a particular situation based upon the circumstances of the site. EPA may change this guidance in the future, as appropriate. EPA and state personnel may use and accept other technically sound approaches, either on their own initiative, or at the suggestion of potentially responsible parties, or other interested parties. Therefore, interested parties are free to raise questions and objections about the substance of this document and the appropriateness of the application of this document to a particular situation. EPA welcomes public comments on this document at any time and may consider such comments in future revisions of this document.
Manganese is one of the most abundant trace elements in the lithosphere and is widely distributed in the environment in over 100 minerals, including various sulfides, oxides, carbonates, silicates, phosphates, and borates (ATSDR, 1998; HSDB). The most common manganese minerals include pyrolusite (manganese dioxide), romanechite, manganite (manganese (III) oxide), and hausmannite (manganese (II, III) oxide)(ATSDR, 1998; HSDB).

The principal uses of manganese are in the manufacturing of steel and alloys (ferromanganese and copper manganese)(Budvari, 1996; HSDB). Manganese compounds may also be released to the environment through their use in batteries, electrical coils, ceramics, matches, glass, dyes, fertilizers (manganese sulfate), oxidizing agents, anti-septics (potassium permanganate), catalysts (manganous acetate), pesticides (potassium permanganate), pigments (manganese sulfate), antiknock agents (methylcyclopentadienyl manganese tricarbonyl), and as animal food additives (manganese sulfate, manganese carbonate). Other important anthropogenic sources of manganese include industrial emissions, combustion of fossil fuels, and landfills (Klaassen et al., 1995; Pisarczyk, 1995; Lewis, 1997; Reidies, 1990; Ashford, 1994; ATSDR, 1998; HSDB).

Manganese compounds are important soil constituents. In soils, redox reactions affect the sorption of manganese compounds which in turn have a considerable effect on soil properties such as cation exchange (Kabata-Pendias, 1992). Background concentrations reported for many metals in U.S. soils are described in Attachment 1-4 of the Eco-SSL guidance (U.S. EPA, 2003). Typical background concentrations of manganese in U.S. soils are plotted in Figure 2.1 for both eastern and western U.S. soils.

Manganese is multi-valent and can exist in the 2+, 3+, 4+, 6+, and 7+ oxidation states, with 2+, 3+, and 4+ being the dominant oxidation states in the environment. Manganese 2+ is the most stable oxidation state in water while manganese 3+ and 4+ compounds are immobile solids. Organic matter may reduce manganese 3+ and 4+ compounds, resulting in the formation of soluble manganese 2+ compounds. Insoluble manganese compounds are formed under aerobic conditions, and soluble compounds are formed under anaerobic conditions from reduction reactions by microorganisms. Soluble manganese compounds are relatively mobile and may leach into surface or ground water (Bodek et al. 1988; HSDB). Soluble manganese is released from soil through ion exchange when replaced by more strongly binding metals such as copper, zinc, or nickel (Bodek et al., 1988;
HSDB). Reducing soil pH and soil aeration increases the solubility of manganese in the soil (WHO 1981; HSDB). In soils, manganese is known to interact with a handful of other elements. Most prominently, manganese is observed to interfere with the availability of cobalt to plants from soils via a strong affinity of manganese oxides to native cobalt. Also, in acidic soils that contain a large amount of manganese, iron absorption by plants can be affected. Interactions also are known to occur between manganese and other heavy metals including cadmium, lead, zinc, and phosphorous (ATSDR, 1998; HSDB).

Manganese is an essential nutrient for both plants and animals. In animals, manganese is associated with growth, normal functioning of the central nervous system, and reproductive function. Specifically, manganese is associated with the formation of connective tissue and bone, carbohydrate and lipid metabolism, and embryonic development of the inner ear (WHO, 1981; HSDB). Manganese deficiency in animals is demonstrated by a reduced growth rate, skeletal abnormalities and abnormal reproductive function (NAP, 1980). Manganese nutritional requirements and typical concentrations in animal feed are discussed in Attachment 4-3 of the Eco-SSL guidance (U.S. EPA, 2003). High levels of manganese may produce neurotoxic responses such as hypoactivity, nervousness, tremors, and ataxia. Other reported effects include liver damage and decreased growth (Clayton and Clayton, 1981-82;1993-94; Venugopal and Luckey, 1978; HSDB).

Manganese is essential in plant nutrition for the oxidation-reduction process. Specifically, manganese participates in the oxygen-evolving system of photosynthesis and in the photosynthetic electron transport system. In the soluble form, manganese is easily taken up from soils by plants and is rapidly translocated throughout the plant. Manganese deficient plants exhibit decreased growth, interveinal chlorosis, necrotic spots on leaves, and browning of roots. Manganese toxicity is demonstrated in plants by iron chlorosis, leaf puckering, necrotic brown spots, and an uneven distribution of chlorophyll in older leaves (Kabata-Pendias, 1992).

The Eco-SSL values derived to date for manganese are summarized in Table 2.1.

<table>
<thead>
<tr>
<th>Plants</th>
<th>Soil Invertebrates</th>
<th>Wildlife</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>220</td>
<td>450</td>
</tr>
<tr>
<td></td>
<td>4,300</td>
<td>4,000</td>
</tr>
</tbody>
</table>

Eco-SSL values were derived for all receptor groups. The Eco-SSL values for manganese range from 220 mg/kg dry weight (dw) for plants to 4,300 mg/kg dw for avian wildlife. The Eco-SSL for plants is less than the 5th percentile of reported background soil concentrations of manganese in western U.S. soils and less than the 50th percentile for eastern U.S. soils (Figure 2.1). The Eco-SSL for soil invertebrates is less than the 50th percentile for western U.S. soils and less than the 75th percentile for eastern U.S. soils (Figure 2.1). The Eco-SSLs for avian and mammalian wildlife are higher than reported range of background concentrations in both western and eastern U.S. soils.
3.0 ECO-SSL FOR TERRESTRIAL PLANTS

Of the papers identified from the literature search process, 407 papers were selected for acquisition for further review. Of those papers acquired, 20 met all 11 Study Acceptance Criteria (U.S. EPA, 2003; Attachment 3-1). Each of these papers were reviewed and the studies were scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). Six study results received an Evaluation Score greater than ten (U.S. EPA, 2003; Attachment 3-1). These studies are listed in Table 3.1.

The studies in Table 3.1 are sorted by bioavailability score. There are four studies eligible for Eco-SSL derivation. These results are used to derive the plant Eco-SSL for manganese (U.S. EPA, 2003; Attachment 3-2). The Eco-SSL is the geometric mean of the maximum acceptable toxicant concentration (MATC) values for three species under different test conditions (pH and % organic matter (OM)) and is equal to 220 mg/kg dw.

4.0 ECO-SSL FOR SOIL INVERTEBRATES

Of the papers identified from the literature search process, 18 papers were selected for acquisition for further review. Of those papers acquired, three met all 11 Study Acceptance Criteria (U.S. EPA 2003; Attachment 3-1). Each of these papers were reviewed and the studies were scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). Three studies received an Evaluation Score greater than ten. These studies are listed in Table 4.1 and were used to derive the soil invertebrate Eco-SSL for manganese (U.S. EPA, 2003; Attachment 3-2). The Eco-SSL is the geometric mean of the EC_{20} values for three test species under different test conditions (pH and OM%) and is equal to 450 mg/kg dw. The studies reported in Table 4.1 were completed specifically for the purpose of Eco-SSL derivation. These studies were conducted under conditions of high bioavailability and represent conservative estimates of toxicity.
<table>
<thead>
<tr>
<th>Reference</th>
<th>IP Number</th>
<th>Test Organism</th>
<th>Soil pH</th>
<th>OM %</th>
<th>Bio-availability Score</th>
<th>ERE</th>
<th>Tox Parameter</th>
<th>Tox Value-Soil Conc. (mg/kg dw)</th>
<th>Total Evaluation Score</th>
<th>Eligible for Eco-SSL Derivation?</th>
<th>Used for Eco-SSL?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reid, 1965</td>
<td>55992</td>
<td>Barley <em>Hordeum vulgare</em></td>
<td>4.6</td>
<td>0.78</td>
<td>2</td>
<td>GRO</td>
<td>MATC</td>
<td>71</td>
<td>16</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Reid, 1965</td>
<td>55992</td>
<td>Barley <em>Hordeum vulgare</em></td>
<td>7.3</td>
<td>0.78</td>
<td>1</td>
<td>GRO</td>
<td>MATC</td>
<td>71</td>
<td>15</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Rehab and Wallace, 1978</td>
<td>46710</td>
<td>Cotton <em>Gossypium spp.</em></td>
<td>6.6</td>
<td>2.4</td>
<td>1</td>
<td>GRO</td>
<td>MATC</td>
<td>707</td>
<td>14</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Foy et al., 1998</td>
<td>11629</td>
<td>Nile grass <em>Heroceras macrum</em></td>
<td>4.62-5.16</td>
<td>0.017 - 4.24</td>
<td>1</td>
<td>GRO</td>
<td>MATC</td>
<td>707</td>
<td>11</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

**Data Not Used to Derive Plant Eco-SSL**

<table>
<thead>
<tr>
<th>Reference</th>
<th>IP Number</th>
<th>Test Organism</th>
<th>Soil pH</th>
<th>OM %</th>
<th>Bio-availability Score</th>
<th>ERE</th>
<th>Tox Parameter</th>
<th>Tox Value-Soil Conc. (mg/kg dw)</th>
<th>Total Evaluation Score</th>
<th>Eligible for Eco-SSL Derivation?</th>
<th>Used for Eco-SSL?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korcak, 1988</td>
<td>13731</td>
<td>Highbush Blueberry <em>Vaccinium corymbosum</em></td>
<td>4.1</td>
<td>1.8</td>
<td>2</td>
<td>GRO</td>
<td>NOAEC</td>
<td>1.5</td>
<td>16</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Gonzalez and Lynch, 1999</td>
<td>18987</td>
<td>Common bean <em>Phaseolus vulgaris</em></td>
<td>5.4</td>
<td>1.9</td>
<td>2</td>
<td>REP</td>
<td>LOAEC</td>
<td>80</td>
<td>15</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

ERE = Ecologically relevant endpoint
GRO = Growth
LOAEC = Lowest observed adverse effect concentration
MATC = Maximum acceptable toxicant concentration. Geometric mean of NOAEC and LOAEC.
N = No

OM = Organic matter content
REP = Reproduction
Y = yes

Bioavailability Score described in Guidance for Developing Eco-SSLs (U.S. EPA, 2003)
Table 4.1  Invertebrate Toxicity Data - Manganese

<table>
<thead>
<tr>
<th>Reference</th>
<th>IP Number</th>
<th>Test Organism</th>
<th>Soil pH</th>
<th>OM%</th>
<th>Bio-availability Score</th>
<th>ERE</th>
<th>Tox Parameter</th>
<th>Tox Value (Soil Conc at mg/kg dw)</th>
<th>Total Evaluation Score</th>
<th>Eligible for Eco-SSL Derivation?</th>
<th>Used for Eco-SSL?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuperman et al., 2002</td>
<td>62344</td>
<td>Potworm <em>Enchytraeus crypticus</em></td>
<td>4.86 - 5.39</td>
<td>1.2</td>
<td>2</td>
<td>REP</td>
<td>EC_{20}</td>
<td>116</td>
<td>17</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Phillips et al., 2002</td>
<td>62345</td>
<td>Springtail <em>Folsomia candida</em></td>
<td>4.56 - 5.29</td>
<td>1.2</td>
<td>2</td>
<td>REP</td>
<td>EC_{20}</td>
<td>1209</td>
<td>18</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Simini et al., 2002</td>
<td>62343</td>
<td>Earthworm <em>Eisenia fetida</em></td>
<td>4.58 - 5.29</td>
<td>1.2</td>
<td>2</td>
<td>REP</td>
<td>EC_{20}</td>
<td>629</td>
<td>16</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

EC_{20} = Effect concentration for 20% of test population  
ERE = Ecologically relevant endpoint  
OM = Organic matter content  
REP = Reproduction  
Y = Yes  
5.0 ECO-SSL FOR AVIAN WILDLIFE

The derivation of the Eco-SSL for avian wildlife was completed as two parts. First, the toxicity reference value (TRV) was derived according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5). Second, the Eco-SSL (soil concentration) was back-calculated for each of three surrogate species representing different trophic levels based on the wildlife exposure model and the TRV (U.S. EPA, 2003).

5.1 Avian TRV

The literature search completed according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-1) identified 3,618 papers with possible toxicity data for either avian or mammalian species. Of these studies, 3,539 were rejected for use as described in Section 7.5. Of the remaining studies, 21 contained data for avian test species. These papers were reviewed and the data were extracted and scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-3 and 4-4). The results of the data extraction and review are provided as Table 5.1. The complete results are included as Appendix 5-1.

Within the reviewed papers, there are 40 results for biochemical (BIO), behavior (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) effects that meet the Data Evaluation Score of >65 for use to derive the TRV (U.S. EPA, 2003; Attachment 4-4). These data are plotted in Figure 5.1 and correspond directly with the data presented in Table 5.1. The no-observed adverse effect level (NOAEL) results for growth and reproduction are used to calculate a geometric mean. This result is examined in relationship to the lowest bounded lowest-observed adverse effect level (LOAEL) for reproduction, growth, and survival to derive the TRV according to procedures in the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5).

A geometric mean of the NOAEL values for reproduction and growth was calculated at 179 mg manganese/kg bw/day. This value is lower than the lowest bounded LOAEL for reproduction, growth, or survival. Therefore, the TRV is equal to the geometric mean of the NOAEL values for reproduction and growth and is equal to 179 mg manganese/kg bw/day.
### Table 5.1
Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV) Manganese

<table>
<thead>
<tr>
<th>Result #</th>
<th>Reference</th>
<th>Test Organism</th>
<th>Route of Exposure</th>
<th>Duration Units</th>
<th>Age</th>
<th>Effect Measure</th>
<th>NOAEL Dose* (mg/kg bw/day)</th>
<th>LOAEL Dose* (mg/kg bw/day)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Martinez and Diaz, 1996</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 14</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>CHM</td>
<td>HMGL</td>
</tr>
<tr>
<td>2</td>
<td>Southern and Baker, 1983</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 14</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>CHM</td>
<td>HMGL</td>
</tr>
<tr>
<td>3</td>
<td>Laskey and Edens, 1985</td>
<td>Japanese quail (Coturnix japonica)</td>
<td>U FD 10</td>
<td>w</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>HRM</td>
<td>TSTR</td>
</tr>
<tr>
<td>4</td>
<td>Southern and Baker, 1983</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 14</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>CHM</td>
<td>HMGL</td>
</tr>
<tr>
<td>5</td>
<td>Southern and Baker, 1983</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 14</td>
<td>d</td>
<td>7</td>
<td>d</td>
<td>JY M</td>
<td>CHM</td>
<td>HMGL</td>
</tr>
<tr>
<td>6</td>
<td>Edens and Laskey, 1990</td>
<td>Japanese quail (Coturnix japonica)</td>
<td>U FD 10</td>
<td>w</td>
<td>0</td>
<td>d</td>
<td>JY M</td>
<td>CHM</td>
<td>HMGL</td>
</tr>
</tbody>
</table>

### Biochemical (BIO)

<table>
<thead>
<tr>
<th>Result #</th>
<th>Reference</th>
<th>Test Organism</th>
<th>Route of Exposure</th>
<th>Duration Units</th>
<th>Age</th>
<th>Effect Measure</th>
<th>NOAEL Dose* (mg/kg bw/day)</th>
<th>LOAEL Dose* (mg/kg bw/day)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Martinez and Diaz, 1996</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 42</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JV M</td>
<td>FDB</td>
<td>FCNS</td>
</tr>
<tr>
<td>8</td>
<td>Black et al., 1985</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 3</td>
<td>w</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>FDB</td>
<td>FCNS</td>
</tr>
<tr>
<td>9</td>
<td>Black et al., 1984</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 21</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>FDB</td>
<td>FCNS</td>
</tr>
<tr>
<td>10</td>
<td>Laskey and Edens, 1985</td>
<td>Japanese quail (Coturnix japonica)</td>
<td>U FD 75</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>FDB</td>
<td>FCNS</td>
</tr>
</tbody>
</table>

### Behavior (BEH)

<table>
<thead>
<tr>
<th>Result #</th>
<th>Reference</th>
<th>Test Organism</th>
<th>Route of Exposure</th>
<th>Duration Units</th>
<th>Age</th>
<th>Effect Measure</th>
<th>NOAEL Dose* (mg/kg bw/day)</th>
<th>LOAEL Dose* (mg/kg bw/day)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Black et al., 1984</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 21</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>PHY</td>
<td>FDCV</td>
</tr>
<tr>
<td>12</td>
<td>Brown and Southern, 1985</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 14</td>
<td>d</td>
<td>4</td>
<td>d</td>
<td>JY M</td>
<td>PHY</td>
<td>FDCV</td>
</tr>
</tbody>
</table>

### Pathology (PTH)

<table>
<thead>
<tr>
<th>Result #</th>
<th>Reference</th>
<th>Test Organism</th>
<th>Route of Exposure</th>
<th>Duration Units</th>
<th>Age</th>
<th>Effect Measure</th>
<th>NOAEL Dose* (mg/kg bw/day)</th>
<th>LOAEL Dose* (mg/kg bw/day)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Halpin et al., 1986</td>
<td>Chicken (Gallus domesticus)</td>
<td>U GV 14</td>
<td>d</td>
<td>8</td>
<td>d</td>
<td>JY M</td>
<td>ORW</td>
<td>ORWT</td>
</tr>
<tr>
<td>14</td>
<td>Laskey and Edens, 1985</td>
<td>Japanese quail (Coturnix japonica)</td>
<td>U FD 70</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>ORW</td>
<td>ORWT</td>
</tr>
</tbody>
</table>

### Growth (GRO)

<table>
<thead>
<tr>
<th>Result #</th>
<th>Reference</th>
<th>Test Organism</th>
<th>Route of Exposure</th>
<th>Duration Units</th>
<th>Age</th>
<th>Effect Measure</th>
<th>NOAEL Dose* (mg/kg bw/day)</th>
<th>LOAEL Dose* (mg/kg bw/day)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Spulkamy et al., 1976</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 7</td>
<td>w</td>
<td>1</td>
<td>w</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>19</td>
<td>Settle et al., 1969</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 4</td>
<td>w</td>
<td>1</td>
<td>d</td>
<td>JY B</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>20</td>
<td>Wedekind and Baker, 1990</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 14</td>
<td>d</td>
<td>8</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>21</td>
<td>Halpin et al., 1986</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 21</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>22</td>
<td>Henry et al., 1986</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 21</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>23</td>
<td>Baker and Halpin, 1991</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 14</td>
<td>d</td>
<td>8</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>24</td>
<td>De Rosa et al., 1980</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 1</td>
<td>w</td>
<td>2</td>
<td>w</td>
<td>JY B</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>25</td>
<td>Brown and Southern, 1985</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 14</td>
<td>d</td>
<td>4</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>26</td>
<td>Black et al., 1985</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 3</td>
<td>w</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>27</td>
<td>Black et al., 1985</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 21</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>28</td>
<td>Wong-Valle et al., 1989</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 21</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>29</td>
<td>Wong-Valle et al., 1989</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 21</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>30</td>
<td>Martinez and Diaz, 1996</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 14</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>31</td>
<td>Southern and Baker, 1983</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 14</td>
<td>d</td>
<td>8</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
<tr>
<td>32</td>
<td>Southern and Baker, 1983</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 14</td>
<td>d</td>
<td>1</td>
<td>d</td>
<td>JY M</td>
<td>GRO</td>
<td>BDWT</td>
</tr>
</tbody>
</table>

### Survival (MOR)

<table>
<thead>
<tr>
<th>Result #</th>
<th>Reference</th>
<th>Test Organism</th>
<th>Route of Exposure</th>
<th>Duration Units</th>
<th>Age</th>
<th>Effect Measure</th>
<th>NOAEL Dose* (mg/kg bw/day)</th>
<th>LOAEL Dose* (mg/kg bw/day)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>Black et al., 1984</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 26</td>
<td>d</td>
<td>4</td>
<td>d</td>
<td>JY B</td>
<td>MOR</td>
<td>MORT</td>
</tr>
<tr>
<td>40</td>
<td>Vohra and Kratzer, 1968</td>
<td>Chicken (Gallus domesticus)</td>
<td>U FD 21</td>
<td>d</td>
<td>NR</td>
<td>NR</td>
<td>JY B</td>
<td>MOR</td>
<td>MORT</td>
</tr>
</tbody>
</table>

Note: *NOAEL and LOAEL values that are equal and from the same reference represent different experimental designs. These are designated with different Phase numbers in Appendix 5.1.

B = body weight changes; BEH = behavior; BIO = biochemical; BL = blood; bw = body weight; CHM = chemical changes; d = day; DR = drinking water; ENZ = enzyme level changes; F = female; FCNS = food consumption; FD = food; FDB = feeding behavior; FDCV = food conversion efficiency; GLUC = glucose; GRO = growth; GV = gavage; HIS = histological changes; HMGL = hemoglobin; ITX = intoxication; JY = juvenile; kg = kilograms; LB = egg laying bird; LI = liver; LOAEL = lowest observed adverse effect level; mg = milligrams; mo = months; M = male; M = measured; MOR = effects on mortality and survival; MORT = mortality; NOAEL = No Observed Adverse Effect Level; NR = Not reported; OR = other oral; ORW = organ weight changes; ORWT = organ weight changes; OTHR = Other; PHY = physiology; PROG = progeny counts/numbers; PTH = pathology; REP = reproduction; SR = serum; TB = tibia; TE = testes; TSTR = testosterone; U = unmeasured; UX = measured but values not reported; w = weeks; WCON = water consumption; WO = whole organism; yr = year.

Eco-SSL for Manganese
April 2007
1) There are at least three results available for two test species within the growth, reproduction, and mortality effect groups. There are enough data to derive a TRV.

2) There are at least three NOAEL results available within the growth and reproduction effect groups for calculation of a geometric mean.

3) The geometric mean is equal to 179 mg manganese/kg bw/day and is lower than the lowest bounded LOAEL for results within the reproduction, growth, and survival (MOR) effect groups.

4) The avian wildlife TRV for manganese is equal to 179 mg manganese/kg bw/day which is the geometric mean of NOAEL values for effects on reproduction and growth.
5.2 Estimation of Dose and Calculation of the Eco-SSL

Three separate Eco-SSL values were calculated for avian wildlife, one for each of three surrogate receptor species representing different trophic levels. The avian Eco-SSLs were calculated according to the Eco-SSL guidance (U.S. EPA, 2003) and are summarized in Table 5.2.

<table>
<thead>
<tr>
<th>Surrogate Receptor Group</th>
<th>TRV for Manganese (mg dw/kg bw/d)</th>
<th>Food Ingestion Rate (FIR)</th>
<th>Soil Ingestion as Proportion of Diet (Ps)</th>
<th>Concentration of Manganese in Biota Type (i) (B_i) (mg/kg dw)</th>
<th>Eco-SSL (mg/kg dw)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avian herbivore (dove)</td>
<td>179</td>
<td>0.190</td>
<td>0.139</td>
<td>B_i = 0.079 * Soil_j where i = plants</td>
<td>4300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avian ground insectivore (woodcock)</td>
<td>179</td>
<td>0.214</td>
<td>0.164</td>
<td>\ln(B_i) = 0.682 * \ln(Soil_j) - 0.809 where i = earthworms</td>
<td>4300</td>
</tr>
<tr>
<td>Avian carnivore (hawk)</td>
<td>179</td>
<td>0.0353</td>
<td>0.057</td>
<td>B_i = 0.0205 * Soil_j where i = mammals</td>
<td>65000</td>
</tr>
</tbody>
</table>

1 The process for derivation of wildlife TRVs is described in Attachment 4-5 of U.S. EPA (2003).
2 Parameters (FIR, P_i, B_i values, regressions) are provided in U.S. EPA (2003) Attachment 4-1 (revised February 2005).
3 B_i = Concentration in biota type (i) which represents 100% of the diet for the respective receptor.
4 HQ = [FIR * (Soil_j * Ps + B_i)] / TRV solved for HQ=1 where Soil_j = Eco-SSL (Equation 4-2; U.S. EPA, 2003).

6.0 ECO-SSL FOR MAMMALIAN WILDLIFE

The derivation of the Eco-SSL for mammalian wildlife was completed as two parts. First, the TRV was derived according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5). Second, the Eco-SSL (soil concentration) was back-calculated for each of three surrogate receptor species based on the wildlife exposure model and the TRV (U.S. EPA, 2003).

6.1 Mammalian TRV

The literature search was completed according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-2) and identified 3,618 papers with possible toxicity data for manganese for either avian or mammalian species. Of these studies, 3,539 were rejected for use as described in Section 7.5. Of the remaining papers, 58 contained data for mammalian test species. These papers were reviewed and the data were extracted and scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-3 and 4-4). The results of the data extraction and review are summarized in Table 6.1. The complete results are provided as Appendix 6-1.
<table>
<thead>
<tr>
<th>Result #</th>
<th>Reference</th>
<th>Test Organism</th>
<th>Method of Animals</th>
<th>Route of Exposure</th>
<th>Exposure Duration</th>
<th>Age</th>
<th>Age Units</th>
<th>Lifestage</th>
<th>Sex</th>
<th>Effect Type</th>
<th>Effect Measure</th>
<th>Response Site</th>
<th>NOAEL Dose* (mg/kg bw/day)</th>
<th>LOAEL Dose* (mg/kg bw/day)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deskin, et al, 1980</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>11.4</td>
<td>77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Mohamed et al, 1986</td>
<td>Rattus norvegicus (Dubreleus dubius)</td>
<td>M</td>
<td>FD</td>
<td>10 d</td>
<td>10 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>IR</td>
<td>F</td>
<td>7.0</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Bhoot et al, 1981</td>
<td>Mouse (Mus musculus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>270</td>
<td>70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Li, et al, 1999</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>262</td>
<td>71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Bonilla and Prasad, 1984</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>129</td>
<td>71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Kontur and Fechter, 1985</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>150</td>
<td>77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Li, et al, 1999</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>24.2</td>
<td>48.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Cunningham et al, 1966</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>3.60</td>
<td>74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Desole, et al, 1995</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>53.3</td>
<td>73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Rehbein et al, 1980</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>877</td>
<td>78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Laskey, et al, 1983</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>24.2</td>
<td>48.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Reid, et al, 1947</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>150</td>
<td>77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Svensson et al, 1985</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>87.0</td>
<td>77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Seeth, et al, 1977</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>150</td>
<td>77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Mapur et al, 1978</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>87.0</td>
<td>77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Derencono et al, 1968</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>100 d</td>
<td>6 w</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>3.60</td>
<td>74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Hartman, et al, 1955</td>
<td>Sheep (Ovis aries)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Halachev and Nikolaov, 1975</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Desole, et al, 1995</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Hintjes and Llewellyn, 1977</td>
<td>Hamster (Mesocricetus auratus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Kristensen, et al, 1965</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Rana, et al, 1985</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Bonilla and Diez-Ewald, 1974</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Komura and Sakamoto, 1991</td>
<td>Mouse (Mus musculus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Komura and Sakamoto, 1991</td>
<td>Mouse (Mus musculus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Komura and Sakamoto, 1991</td>
<td>Mouse (Mus musculus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Komura and Sakamoto, 1991</td>
<td>Mouse (Mus musculus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Bonilla, et al, 1985</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Chandra and Shukla, 1979</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Bonilla, 1980</td>
<td>Rat (Rattus norvegicus)</td>
<td>U</td>
<td>FD</td>
<td>80 d</td>
<td>66-69 d</td>
<td>JV</td>
<td>B</td>
<td>CHM</td>
<td>NORE</td>
<td>F</td>
<td>64.8</td>
<td>76</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Table 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

<table>
<thead>
<tr>
<th>Result #</th>
<th>Reference</th>
<th>Test Organism</th>
<th>No of Conc/Doses</th>
<th>Method of Analyses</th>
<th>Exposure Duration</th>
<th>Dose Units</th>
<th>AGE</th>
<th>Sex</th>
<th>Effect Type</th>
<th>Effect Site</th>
<th>NOAEL Dose* (mg/kg bw/day)</th>
<th>LOAEL Dose* (mg/kg bw/day)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>61</td>
<td>Grummer et al, 1950</td>
<td>Pig (Sus scrofa)</td>
<td>2 U</td>
<td>FD</td>
<td>124 d</td>
<td>9</td>
<td>GE</td>
<td>F</td>
<td>REP</td>
<td>PROG</td>
<td>WO</td>
<td>2.83</td>
<td>71</td>
</tr>
<tr>
<td>62</td>
<td>Rehnberg et al, 1980</td>
<td>Rat (Rattus norvegicus)</td>
<td>4 U</td>
<td>GV</td>
<td>20 d</td>
<td>1 d</td>
<td>JV</td>
<td>B</td>
<td>REP</td>
<td>RHS</td>
<td>TE</td>
<td>21.0</td>
<td>71.0</td>
</tr>
<tr>
<td>63</td>
<td>USDA, 1973</td>
<td>Pig (Sus scrofa)</td>
<td>35143 U</td>
<td>Rabbit (Oryctolagus cuniculus)</td>
<td>5 U</td>
<td>GV</td>
<td>12 d</td>
<td>NR</td>
<td>NR</td>
<td>GE</td>
<td>F</td>
<td>REP</td>
<td>WO</td>
</tr>
<tr>
<td>64</td>
<td>USDA, 1973</td>
<td>Mouse (Mus musculus)</td>
<td>35143 U</td>
<td>Mouse (Mus musculus)</td>
<td>5 U</td>
<td>GV</td>
<td>9 d</td>
<td>NR</td>
<td>NR</td>
<td>GE</td>
<td>F</td>
<td>REP</td>
<td>WO</td>
</tr>
<tr>
<td>65</td>
<td>USDA, 1973</td>
<td>Pig (Sus scrofa)</td>
<td>35143 U</td>
<td>Guinea pig (Mesocricetus auratus)</td>
<td>5 U</td>
<td>GV</td>
<td>4 d</td>
<td>NR</td>
<td>NR</td>
<td>GE</td>
<td>F</td>
<td>REP</td>
<td>WO</td>
</tr>
<tr>
<td>66</td>
<td>Pappas et al, 1997</td>
<td>Rat (Rattus norvegicus)</td>
<td>33496 U</td>
<td>Rat (Rattus norvegicus)</td>
<td>3 U</td>
<td>DR</td>
<td>30 d</td>
<td>NR</td>
<td>NR</td>
<td>GE</td>
<td>F</td>
<td>REP</td>
<td>PRWT</td>
</tr>
<tr>
<td>67</td>
<td>Kontur and Fechter, 1985</td>
<td>Rat (Rattus norvegicus)</td>
<td>34752 U</td>
<td>Rat (Rattus norvegicus)</td>
<td>4 U</td>
<td>FD</td>
<td>21 d</td>
<td>1 d</td>
<td>JV</td>
<td>B</td>
<td>REP</td>
<td>PRWT</td>
<td>WO</td>
</tr>
<tr>
<td>68</td>
<td>Laskey et al, 1982</td>
<td>Rat (Rattus norvegicus)</td>
<td>56 U</td>
<td>FD</td>
<td>43 d</td>
<td>NR</td>
<td>NR</td>
<td>GE</td>
<td>F</td>
<td>REP</td>
<td>PRWT</td>
<td>WO</td>
<td>291</td>
</tr>
<tr>
<td>69</td>
<td>Leung et al, 1982</td>
<td>Rat (Rattus norvegicus)</td>
<td>34895 U</td>
<td>Rat (Rattus norvegicus)</td>
<td>3 U</td>
<td>DR</td>
<td>26 d</td>
<td>NR</td>
<td>NR</td>
<td>GE</td>
<td>F</td>
<td>REP</td>
<td>PRWT</td>
</tr>
<tr>
<td>70</td>
<td>Becker and McCollum, 1938</td>
<td>Rat (Rattus norvegicus)</td>
<td>14459 U</td>
<td>Rat (Rattus norvegicus)</td>
<td>5 U</td>
<td>FD</td>
<td>730 d</td>
<td>NR</td>
<td>NR</td>
<td>JV</td>
<td>M</td>
<td>REP</td>
<td>TEGD</td>
</tr>
<tr>
<td>71</td>
<td>Bataineh et al, 1998</td>
<td>Rat (Rattus norvegicus)</td>
<td>1717 U</td>
<td>DR</td>
<td>12 d</td>
<td>NR</td>
<td>NR</td>
<td>AD</td>
<td>M</td>
<td>REP</td>
<td>TEWT</td>
<td>TE</td>
<td>26.4</td>
</tr>
<tr>
<td>72</td>
<td>Laskey et al, 1985</td>
<td>Pig (Sus scrofa)</td>
<td>34755 U</td>
<td>Rat (Rattus norvegicus)</td>
<td>2 U</td>
<td>GV</td>
<td>21 d</td>
<td>0 d</td>
<td>JV</td>
<td>M</td>
<td>REP</td>
<td>TEWT</td>
<td>TE</td>
</tr>
</tbody>
</table>

ACTV = activity; general; AGGT = agression; ATPT = adenosine triphosphate; B = both; BDWT = body weight changes; BEH = behavior; BIO = biochemical; BL = blood; BO = bone; BR = brain; bw = body weight; CALC = calcium; CHM = chemical changes; CHOL = cholesterol; CRKI = creatine kinase; d = day; DOPA = dopamine; DR = drinking water; ENZ = enzyme level changes; F = female; FCNS = food consumption; FD = food; FDB = feeding behavior; FDCTV = food conversion efficiency; GHIV = general behavioral changes; GCM = general biochemical changes; GE = gestation; GENZ = general enzyme changes; GGRO = general growth; GHS = general histology; GHRM = general hormonal changes; GLYC = glycine; GRO = growth; GV = gavage; HIS = histological changes; HMG = hemoglobin; IN = intestinal tract; ITX = intoxication; JV = juvenile; kg = kilograms; LC = lactation; LI = liver; LOAEL = lowest observed adverse effect level; mg = milligrams; mo = months; M = male; M = measured; MOR = effects on mortality and survival; NCR = necrosis; NMVM = number of movements; NOAEL = No Observed Adverse Effect Level; OR = oral; ORW = organ weight change; ORWH = organ weight changes; OTHR = Other; PHY = physiology; PL = plasma; PROG = progeny counts/numbers; PRTL = protein, total; PRWT = progeny weight; PTH = pathology; RBCE = red blood cell count; REP = reproduction; RHS = reproductive organ histology; RSPST = response time to stimulus; SCDH = succinate dehydrogenase; SK = skin; SM = sexually mature; SMIX = weight relative to body weight; SP = spleen; SR = serum; SURV = survival; TB = testis; TEGD = testes degeneration; TEWT = testes weight; TSTR = testosteron; TAA = amino acids, total; TWBC = white blood cell count, total; TYRO = tyrosine; U = unmeasured; UX = measured but values not reported; w = weeks; WCON = water consumption; WO = whole organism; yr = year.

*NOAEL and LOAEL values that are equal and from the same reference represent different experimental designs. These are designated with different Phase numbers in Appendix 5.1.
Within the reviewed papers there are 109 results for biochemical (BIO), behavior (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) endpoints with a total Data Evaluation Score >65 that were used to derive the TRV (U.S. EPA 2003; Attachment 4-4). These data are plotted in Figure 6.1 and correspond directly with the data presented in Table 6.1. The NOAEL results for growth and reproduction are used to calculate a geometric mean NOAEL. This geometric mean is examined in relationship to the lowest bounded LOAEL for reproduction, growth, and survival to derive the TRV according to the Eco-SSL guidance (U.S. EPA 2003; Attachment 4-5).

A geometric mean of the NOAEL values for reproduction and growth was calculated at 51.5 mg manganese/kg bw/day. This value is lower than the lowest bounded LOAEL for reproduction, growth, or mortality results. Therefore, the TRV is equal to the geometric mean of the NOAEL values for reproduction and growth and is equal to 51.5 mg manganese/kg bw/day.

### 6.2 Estimation of Dose and Calculation of the Eco-SSL

Three separate Eco-SSL values were calculated for mammalian wildlife, one for each of three surrogate receptor groups representing different trophic levels. The mammalian Eco-SSLs derived for manganese were calculated according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5) and are summarized in Table 6.2.

<table>
<thead>
<tr>
<th>Surrogate Receptor Group</th>
<th>TRV for Manganese (mg dw/kg bw/d)</th>
<th>Food Ingestion Rate (FIR)</th>
<th>Soil Ingestion as Proportion of Diet (P)</th>
<th>Concentration of Manganese in Biota Type (i)</th>
<th>Eco-SSL (mg/kg dw)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammalian herbivore (voles)</td>
<td>51.5</td>
<td>0.0875</td>
<td>0.032</td>
<td>B_i = 0.079 * Soil_i where i = plants</td>
<td>5300</td>
</tr>
<tr>
<td>Mammalian ground insectivore (shrew)</td>
<td>51.5</td>
<td>0.209</td>
<td>0.030</td>
<td>ln(B_i) = 0.682 * ln(Soil_i) - 0.809 where i = earthworms</td>
<td>4000</td>
</tr>
<tr>
<td>Mammalian carnivore (weasel)</td>
<td>51.5</td>
<td>0.130</td>
<td>0.043</td>
<td>B_i = 0.0205 * Soil_i where i = mammals</td>
<td>6200</td>
</tr>
</tbody>
</table>

1 The process for derivation of wildlife TRVs is described in Attachment 4-5 of U.S. EPA (2003).
2 Parameters (FIR, P, B, values, regressions) are provided in U.S. EPA (2003) Attachment 4-1 (revised February 2005).
3 B = Concentration in biota type (i) which represents 100% of the diet for the respective receptor.
4 HQ = [FIR * (Soil_i * P_i + B_i)] / TRV solved for HQ=1 where Soil_i = Eco-SSL (Equation 4-2; U.S. EPA, 2003).
1) There are at least three results available for two test species within the growth, reproduction, and mortality effect groups. There are enough data to derive a TRV.

2) There are three NOAEL results available within the growth and reproduction effect groups for calculation of a geometric mean.

3) The geometric mean is equal to 51.5 mg manganese/kg bw/d and is lower than the lowest bounded LOAEL for results within the reproduction, growth, and survival (MOR) effect groups.

4) The mammalian wildlife TRV for manganese is equal to 51.5 mg Mn/kg bw/day which is the geometric mean of NOAEL values within the reproduction and growth effect groups.
7.0 REFERENCES

7.1 General Manganese References


---

*Eco-SSL for Manganese* 15 April 2007
7.2 References for Plants and Soil Invertebrates


7.3 References Rejected for Use in Deriving Plant and Soil Invertebrate Eco-SSLs

These references were reviewed and rejected for use in derivation of the Eco-SSL. The definition of the codes describing the basis for rejection is provided at the end of the reference sections.


<table>
<thead>
<tr>
<th>Source</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rev</strong></td>
<td>Checkai, R., Kuperman, R., Simini, M., Phillips, C., Speicher, J., and Barclift, D. 2001. Developing Soil Invertebrate Benchmarks for Barium (Ba), Beryllium (Be), Manganese (Mn), and Antimony (Sb) as Ecological Soil Screening Levels. Presented at SETAC, Nov.11-14, 2001, Baltimore, MD : 1 p. (2001)</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Year</th>
<th>Authors</th>
<th>Title</th>
<th>Journal/Source</th>
</tr>
</thead>
</table>

*Eco-SSL for Manganese* 21  
April 2007


<table>
<thead>
<tr>
<th>Species</th>
<th>Authors</th>
<th>Reference</th>
</tr>
</thead>
</table>


No Control Luwe, Michael W. F., Nilsson, L. O., Huttl, R. F., and Johansson, U. T Eds. 1995. Distribution of nutrients and phytotoxic metal ions in the soil and in two forest floor plant species of a beech (*fagus*)


Media

Media

ERE

Mix

Media

OM, pH

Mix

OM, pH

Media

OM, pH

OM, pH

OM, pH

OM, pH

Media

Score


ERE

No Dose

Media

No Conc

OM, pH

OM, pH
Von Rosen, G. 1964. Mutations Induced by the Action of Metal Ions in Pisum. II. Further Investigations on the Mutagenic Action of Metal Ions and Comparison with the Activity of Ionizing Radiation. Hereditas. 51: 89-134 (1964)

OM, pH

OM, pH

OM, pH

Media

OM, pH

OM, pH

OM, pH

OM, pH

OM, pH


7.4 References Used in Deriving Wildlife TRVs


Bonilla, E. 1978. increased gaba content in caudate nucleus of rats after chronic manganese chloride administration. **J Neurochem; 31 (2).** 551-552 Ref ID: 34677


Leeson, S. and Summers, J. D. 1982. effect of high dietary levels of supplemental zinc manganese copper or iron on broiler performance to 3 weeks of age and accumulation of these minerals in tissue and excreta. Nutr Rep Int. 25(3): 591-599. Ref ID: 2196


Eco-SSL for Manganese 38 April 2007

Reid, JT, Pfau, OK, Salisbury, RL, Bender, CB, and Ward, GM. 1947. mineral metabolism studies in dairy cattle. i. the effect of manganese and other trace elements on the metabolism of calcium and phosphorus during early lactation. *J. Nutr.* 34: 661. Ref ID: 14471


7.5 References Rejected for Use in Derivation of Wildlife TRV

These references were reviewed and rejected for use in derivation of the Eco-SSL. The definition of the codes describing the basis for rejection is provided at the end of the reference sections.

Unrel addition of calcium ions for enhancing the safety of metal-ligand chelates as magnetic resonance imaging agents and x-ray contrast agents.  
PCT Int. Appl. 10 pp.

Diss adriamycin cardiotoxicity and essential trace metal homeostasis in the in vivo rat heart (doxorubicin, cardiomyopathy, manganese, iron).  
901491 ORDER NO: AAD85-26534

In Vit 1992.  
AFRRI-SR92-1; AFRRI-SR92-2

No Oral amino acid-chelated compositions and method for delivery of divalent metal cations to specific biological tissue sites.  
PCT Int. Appl. 42 pp.

Not Avail amino acid metal complexes using hydrolyzed protein as the amino acid source and methods re same.  

No dose animal feed containing carboxylic acids.  
PCT Int. Appl. 36 pp.

Department of Agricultural Technical Services, South Africa: 270 pp.

Diss an approach to direct imaging of brain activation with mri by activity-induced manganese dependent, "aim", contrast.  
01618836 ORDER NO: AAD98-13840

Mix aqueous feed additive comprising lactic acid, organic acid and chelated trace elements.  
PCT Int. Appl. 15 pp.

Diss arsenic: an analytical procedure to determine its total content in biological samples and signs of its deprivation in rats and chicks.  
788794 ORDER NO: AAD82-20750

No Oral 251. Assessment of Toxicity of Automotive Metallic Emissions. Volume II.  
<NOTE> Final Rept | 
AU- Holbrook, D. J. | CS- North Carolina Univ.,

FL birds and fowls fodder additive prescription and its prepn.  
Faming Zhanli Shengqiang Gongkai Shuomingshu: 10 pp.

No Oral central nervous system toxicity of manganese: mechanism of manganese concentration in the ventral mesencephalon (choroid plexus, dopamine reuptake).  
01565449 ORDER NO: AAD97-20597

Diss characterization of a deaf, vertiginous mutant rat (recessive mutation, waltzing, rodent).  
905356 ORDER NO: AAD85-29709

Diss chromium-nutrient interactions affecting tissue chromium, vitamin c metabolism, and cholesterol synthesis.  
01135479 ORDER NO: AAD90-35204

Diss a comparative study: magnetic resonance imaging (mri) of normal kidney and renal pathologies using paramagnetic contrast agents.  
01117130 ORDER NO: AAD90-22181
Eco-SSL for Manganese

April 2007
development of experimental cardiac failure in rat (mRNA, ischemia, superoxide dismutase, manganese, copper-zinc). 01476944 ORDER NO: AADAA-IC484409


Diss expression of antioxidant enzymes in copper deficient rat brain, heart, and liver. 01452581 ORDER NO: AADAA-I9543281

Diss factors affecting manganese homeostasis in the chick. 920649 ORDER NO: AAD86-10932


Diss functional assessment of manganese status (superoxide dismutase, biliary excretion). 01447018 ORDER NO: AADAA-I9527297


Diss heavy metal bioaccumulation in great basin submerged aquatic macrophytes. 01363274 ORDER NO: AAD94-18488

Diss high field NMR studies of static ordering and spin-energy coupling in manganese-fluoride. 763588 ORDER NO: AAD81-26872

Diss interactions among zinc, copper, iron, manganese, and ascorbic acid in the japanese quail (dietary supplements, toxicity, perosis, trace elements, anemia). 887582 ORDER NO: AAD85-14498

Diss intracellular distribution of manganese and the effect of dietary manganese on rat liver arginase. 219135 ORDER NO: AAD59-01610

Diss investigation of dietary zinc and linoleic acid interactions in the sprague-dawley rat (rat). 1076906 ORDER NO: AAD89-21281

Diss involvement of cations in temperature regulation in chickens. 694062 ORDER NO: AAD80-20524


Diss kinetic modelling of iron-52/manganese-52m-citrate in brain by positron emission tomography (PET) (blood brain barrier). 01654257 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.


Diss manganese absorption: studies in humans with special reference to infant diets. 01132607 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

Diss manganese metabolism as affected by dietary calcium and phosphorus (calcium, phosphorus). 1079758 ORDER NO: AAD89-22450
manganese toxicity in the developing rat brain: the involvement of monoamine systems (catecholamines, amphetamine, neurotoxicology). 847139 ORDER NO: AAD84-14290

manganese utilization as affected by excess calcium and phosphorus. 01157849 ORDER NO: AAD91-14455

melanin binding of mptp and related substances, and manganese: possible connection with parkinsonism. 01215314 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

the metabolism and toxicology of manganese. 873743 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

metabolism of zinc, iron, copper and manganese of men and rats as affected by dietary protein, calcium and phosphorus. 799169 ORDER NO: AAD82-24068


method of increasing amino acids content in grains of cereals and legumes by treatment with ammonia or urea. Czech. 5 pp.

method to accelerate the color forming reaction between an enzyme and an indolyl derivative by adding a free radical and/or chelate to the reaction medium and its application for immunoassays and immunochromatography. Ger. Offen. 16 pp.


methods using manganese superoxide dismutase-deficient mouse for testing compounds for use as therapeutic antioxidants. PCT Int. Appl. 47 pp.

methylcyclopentadienyl manganese tricarbonyl teratology study in rats with attached appendices and cover letter dated 031480. EPA/OTS; Doc #88-7900211

dissociative molecules useful for biological and medical applications: part i. toward the development of free radical based photoaffinity labels. part ii. new nitroxide formulations as contrast-enhancing agents for magnetic resonance imaging. part iii. mammalian brain sigma receptor specific ligands: structures and molecular mechanics calculations. 0991651 ORDER NO: AAD88-08702

nutrient availability of wheat feed screenings in broiler diet (chicken). 808758 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

part i. phosphorus requirements of range beef cattle. part ii. effects of high levels of manganese supplementation on reproduction and lactation of beef cattle, and rabbits, and on the fecal excretion of calcium and phosphorus by steers. 088045 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

phospholipase c (pi-plc) in adipose tissue of the ob/ob mouse. 01209355 ORDER NO: AAD92-08517]
phosphorylase phosphatase: interconversion of active and inactive forms (manganese). 

ORDER NO: AAD84-12371

the physiology of the calcium leak channel and calcium regulation in muscle and nervous tissue of the dystrophic mdx mouse (muscular dystrophy, dystrophin).

ORDER NO: AADAA-19602450

plant cell preparation for stimulating fermentation and other physiological functions.  


pneumotoxic properties of the fuel additive methylcyclopentadienyl manganese tricarbonyl (mmt): part i. the role of the sympathetic nervous system in mmt-induced pneumotoxicity and mortality. part ii. mmt-induced pneumotoxicity and lethality which is independent of sympathetic nervous system activity. 

ORDER NO: AAD87-11210

preparation of biologic inorganic composite feed additive for animals and fowls.  


protein-based thermoplastic chewable pet toy.  

PCT Int. Appl.  30 pp.

regulation of manganese superoxide dismutase activity in x-irradiated mouse heart (induction). 

ORDER NO: AAD84-28257

a role for the mitochondrion in manganese toxicity. 

ORDER NO: AAD91-32404

role of copper in the phenotypic expression of scoliosis. 

ORDER NO: AAD84-16905

a segment ii teratology study on methylcyclopentadienyl manganese tricarbonyl in rats with attachment and cover letter dated 100378|so- numbers not reported) fed methylcyclopentadienylmanganeseetricarbonyl (mmt), by gavage (dose levels and dosing period not reported). the authors concluded that the data did not support a conclusion that mmt was a teratogen. however, high dose levels produced high maternal and embryonal toxicity, which may have obscured potential teratogenic effects. the document summarizes this study, and no further information is available regarding experimental method or results.

PERM/OTS; Doc #88-7900211

somatotropin-transition metal complexes as animal growth stimulants and a method for their preparation.  

Eur. Pat. Appl.  10 pp. C.

studies on the muscarinic receptors in neuroblastoma cells. 

ORDER NO: AAD81-14988

studies on the relation of manganese to the nutrition of the mouse. the effect of diet on the manganese content of milk.

ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

a study of membrane proteins and ion transport processes in red blood cells of the spontaneously hypertensive and wistar-kyoto rats.  

ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

a study of the chemistry and mutagenicity of welding fume.  

ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.
Nut 

Nut 

Drug 

Not Avail 

Diss 
zinc and calcium effects on nickel dermatitis in the guinea pig. 0961875 ORDER NO: AAD87-17748

FL 

FL 
Abd El-Fadil Ibrahim Hassan, H. 1988.*Influence of the Heavy Metals Lead, Cadmium, Zinc, Manganese, Copper, Mercury and Beryllium on the Glutathione S-Transferases in the Rat Liver.*<Original> Einfluss Der Schwermetalle Pb, Cd, Zn, Cu, Hg Und Be Blei, Cadmium, Zink, Mangan, Kupfer, Quecksilber Und Beryllium Auf Die Glutathion-S-Transferasen Der Rattenleber

Nut def 

Surv 

FL 

Phys 

Surv 

CP 

Bio Acc 

No Oral 

Unrel 


FED PROC. Federation Proceedings. 32 (3 Part 1). 1973 929


Journal of Animal Science. 42 (1). 1976 243

FED PROC. Federation Proceedings. 35 (3). 1976 256


No Oral  Adachi, Shuichi, Takemoto, Kazuo, Hirouse, Toshiko, and Hosogai, Yuutaro. spontaneous and 2-nitropropane induced levels of 8-hydroxy-2'-deoxyguanosine in liver dna of rats fed iron-deficient or manganese- and copper-deficient diets.  


Diss Ahpasri Chaigool. 1985. genotoxicity of some heavy metals on chick embryos. *original> phit khong loha nak bangchanit to san phanthukam nai embryo kai. 83 Leaves


Nut Amer, A. A. Azhar Univ. Cairo Egypt Faculty of Agriculture, Abdel-Hakim, N. F., Attia, F. M., and El-Gallad, T. T. 1985. studies on dietary manganese requirements of growing chicks egypt. Al-Azhar Journal of Agricultural Research. V. 4 P. 201-214


---

*Eco-SSL for Manganese* 52  April 2007


Abstract


Species


Gene


CP


In Vit


In Vit


Rev


Nut def


In Vit


Fate


Abstract


Meth


In Vit


Unrel


Attisier, N. 1974. [mn2+ uptake by mitochondria after liver infusion in normal and thyroidectomized rats]. <original> captation de mn2+ par les mitochondries aprés perfusion du foie de rat normal et thyroidectomise. *Comptes Rendus Des Seances De La Societe De Biologie Et De Ses Filiales*


Barhoum, S. 1989. influence of a moderate phosphorus deficiency on the ash content andmineral status of different parts of the body of goats. 595-602.


FL Barkhatov, N. A. 1978. the effect of trace elements on metabolism and reproductive function. *Veterinariya, Moscow, USSR (1):* 76-79.

FL Barkhatov, N. A. 1978. trace elements for restoring normal reproductive function in swine (cobalt, zinc, manganese). *Veterinariya, Moscow, USSR. (No.8):* 75-78.


Bencko, V., Arbetova, D., and Skupenova, V. 1981. use of domesticated rabbit tissues for monitoring of environmental pollution by toxic metals (mn, pb, cr, cd, ni). *Journal of Hygiene, Epidemiology, Microbiology, and Immunology* 25(2)

Benell-Young, L. I(a) and Bendell, J. F. 1999. grit ingestion as a source of metal exposure in the spruce grouse, dendragapus canadensis. *Environmental Pollution.* 106(3): 405-412.


**CP**


**FL**


**Unrel**


**In Vit**


**Unrel**


**Nut**


**FL**


**Surv**


**Bio Acc**


**Unrel**


**Herp**


<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bruemmer, J. E(A), Rueda, B. R., Hawkins, D. E(A), Ross, T. T(A), Hallford, D. M. A, Botros, I. W., Renner, R. A(A), and Hoyer, P. B. 1996.</td>
<td>steady state levels of mRNAs encoding manganese superoxide dismutase (mnsod), copper/zinc superoxide dismutase (cu/znsod), catalase (cat) and glutathione peroxidase (gshpx) in the bovine corpus luteum (bcl) throughout the estrous cycle.</td>
</tr>
<tr>
<td>Bruen, P. a Rd, Sousa, J. D., Comastri Filho Ja, and Almeida, I. LD. 1987.</td>
<td>mineral deficiencies of cattle in paiaugus region in pantanal mato-grossense brazil ii. copper zinc manganese and iron.</td>
</tr>
<tr>
<td>Buchthal, S. D. and Bell, R. G. 1983.</td>
<td>vitamin k dependent carboxylation of glutamate residues to gamma-carboxyglutamate in microsomes from spleen and testes: comparison with liver, lung, and kidney.</td>
</tr>
<tr>
<td>Biochemistry 22(5): 1077-82.</td>
<td></td>
</tr>
<tr>
<td>Molochnoe i Myasnoe Skotovodstvo (2): 56-57.</td>
<td></td>
</tr>
<tr>
<td>Bugdaev, I., Kokorev, V., and Arylov, A. 1988.</td>
<td>the effect of manganese levels in rations on the growth and development of bull calves young beef cattle. &lt;original&gt; vliyanie raznykh urovnej manganata v ratsionakh na rost i razvitie bychkov.</td>
</tr>
<tr>
<td>Molochnoe i Myasnoe Skotovodstvo. (No.2) P. 56-57</td>
<td></td>
</tr>
<tr>
<td>Zhivotnovodstvo (5): 42-44.</td>
<td></td>
</tr>
<tr>
<td>Biological Trace Element Research. 46(1/2): 67-78.</td>
<td></td>
</tr>
<tr>
<td>Toxicol. V98. N1-3. P57(9)</td>
<td></td>
</tr>
<tr>
<td>Bull, R. J. 1978.</td>
<td>paradoxical decrease in corpus striatal manganese concentrations with manganese load.</td>
</tr>
</tbody>
</table>

J Lab Clin Med.  86(1): 132-139.


Alt  Burch, Robert E. and Hahn, Henry K. J. 1982. the effect of aging on rat tissue content of moisture, protein, zinc, copper, and manganese with partial food deprivation: ii. middle stages of aging.  
Age (Omaha Nebr.)  5(3): 80-6.


Nut  Burdelev, T. E., Kokorina, E. K., and Ivanova, L. Ya. the growth and development of calves in addition of vitamins and poly salt trace elements to the feed.  
Izvestiya Timiryazevskoi Sel'Skokhozyaistvennoi Akademii.  0 (5). 1979. 137-144.

AUK.  113(2): 399-407.

Bio Acc  Burger, J. 1997. heavy metals and selenium in herring gulls (larus argentatus) nesting in colonies from eastern long island to virginia.  


Herp  Burger, J. and Gibbons, J. W. 1998. trace elements in egg contents and egg shells of slider turtles (trachemys scripta) from the savannah river site.  
Arch.Environ Contam Toxicol.  34(4): 382-386.

Bio Acc  Burger, J. and Gochfeld, M. 1997. age differences in metals in the blood of herring gull (larus argentatus) and franklin's (larus pipixcan) gulls.  

Surv  Burger, J. and Gochfeld, M. 1997. age differences in metals in the blood of herring (larus argentatus) and franklin's (larus pipixcan) gulls.  
Archives of Environmental Contamination and Toxicology  33(4): 436-440.


Environmental Toxicology and Chemistry  14(7): 1233-1239.


Burgess, S. L. The response of swine to different amounts of dietary manganese. *Georgia Agricultural Experiment Stations Research Report.* 250. 1977 3-10


Chen Xiyu, Ye Chenliang, Cao Shengfeng (Shanghai Agricultural Coll. (China)), and Chen Guigen. 1990. The effect of dietary manganese on the mn concentrations in serum, testis and small intestine of the stud-cocks. *Journal of Shanghai Agricultural College. V. 8(4) P. 313-317*


Unrel Chowdhury, N. and Rajvir Singh. 1993. distribution of some elements in hydatid cysts of echinococcus granulosus from buffalo (*Bubalus bubalis*). *Journal of Helminthology.* V. 67(2) P. 112-114


Cikrt, M., Lepsi, P., Lukas, E., Sperlingova, I., Horakova, L., and Jones, M. M. 1987. the effect of some chelating agents on the biliary and urinary excretion of manganese in rats. *Journal of Hygiene, Epidemiology, Microbiology, and Immunology* 31(1)


embryotoxicity and fetotoxicity of manganese in mice: variability with the day of exposure. 

No Oral  Colomina, MT, Domingo, JL, Llobet, JM, and Corbella, J.  1996.  effect of day of exposure on the 

In Vit  Colson A-M, Labaille, F., and Goffeau, A.  1976.  a cytoplasmic gene for partial suppression of a 
nuclear pleiotropic respiratory deficient mutant in the petite negative yeast schizosaccharomyces-

by luminal ca2+ contributes to quantal ca2+ mobilization.  EMBO Journal  15(9): 2086-93.


Nut def  Conde-Martel, A., Gonzalez-Reimers, E., Santolaria-Fernandez, F., Castro-Aleman, V., Galindo-
Martin, L., Rodriguez-Moreno, F., and Martinez-Riera, A.  1992.  combined effects of ethanol and 
protein deficiency on hepatic iron, zinc, manganese, and copper contents.  Alcohol (N. Y.) (1992) 

FL  Conde Martel, A., Gonzalez Reimers, E., Santolaria Fernandez, F., Castro Aleman V, Marchena 
Gomez, J., and Martinez Riera, A.  1993.  [liver changes in protein malnutrition. an experimental 
study in rats].  <original> cambios hepaticos en la malnutricion proteica. estudio experimental en 

Alt  Conrad, G. W. and Woo M-L.  1980.  synthesis of 3’ phospho adenosine 5’ phospho sulfate 
increases during corneal development.  Journal of Biological Chemistry.  255 (7). 1980. 3086-
3091.

effect of trace minerals chelated with polyphosphate on biochemicalindices in pigs.  Lucrari 

Diss  Cook, M. E.  1983.  leg weakness: interactions of avian reoviruses and nutrition in diseaseand 

reovirus-infected chickens fed various dietary levels of choline, folic acid, manganese, biotin, 

Abstract  Cope, F. O., Stuart, M., and Stake, P. E.  1979.  effects of increased dietary manganese or vitamins 
on the development of perosis in battery reared male broiler chicks.  Federation Proceedings 
38(3, I): 557.

In Vit  Copin, J. C(A), Ledig, M., and Tholey, G.  1994.  alteration of astrocyte metabolism during the 

FL  Coraboeuf, Edouard and Vassort, Guy.  1967.  effects of tetrodotoxin, tetraethylammonium, and 
Nut
Corah, L. Kansas State Univ. Manhattan KS USA. 1996. trace mineral requirements of grazing cattle. *Animal Feed Science Technology*. V. 59(1-3) P. 61-70

Rev

FL

Diss
Corella Vargas, R. CS Universidad de Costa Rica San Jose. Facultad. [effect of high levels of manganese in diet on thyroid, reproductive function and iron metabolism in rats]. <original> efectos de altos niveles de manganeso en la dieta sobre la funcion tiroidea, reproductora y el metabolismo de hierro en ratas. 120 P. | LA- Spanish| SL- Spanish| NT- 120 Ref| CP- Costa Rica| DT-

FL

Acu

HHE

FL

In Vit

Species

Bio Acc

In Vit

CP

Abstract

Nut

Abstract


CP Dallas, D. V(A), Keeney, S. E(A), Palkowetz, K. H(A), Rudloff, H. E(A), Tarrant D(A), and Schmalstieg, F. C(A). 1999. manganese superoxide (mnsod) expression in the neonatal rat exposed to hyperoxia. *Pediatric Research* 45(4 PART 2): 299A.

Mineral

Rev

Unrel

FL

Plant

In Vit

No Oral

Surv

Bio Acc

Bio Acc

Alt

Dead

Urel

Prim


Mix

Demko, E. B. 1970. [an increase in the role of iodine in combination with other trace elements in pathologic conditions of the thyroid gland]: <original> o povyshenii roli ioda v sochetanii s drugimi mikroelementami pri ptologicheskikh sostoianiakh shchitovidnoi zhelezy. Probi Endokrinol (Morsk). 16(5): 102-6.

FL


Urel


FL


Unrel


Unrel


FL


No Oral


In Vit


Unrel


In Vit


Unrel


RP


In Vit


Djahanschiri, H., Omid-Fard, N., and Brune, H. 1975. [the reciprocal action of physiological levels of dietary iron and manganese on growth and their retention in the rat]. *Zeitschrift Fur Tierphysiologie, Tierernahrung Und Futtermittelkunde*;


CP  Dove, C. R. 1990. factors affecting the efficacy of growth promoting levels of coppersulfate in swine diets. 63-72.


Abstract

Unrel

FL

Unrel

FL

No COC

Nut def

Species

In Vit

Nut

In Vit

FL

FL

No Tox
Economides, S. 1987. intensive lamb fattening. 4. the effect of feeding pelleted or mash diets supplemented with trace elements and/or vitamins on the performance of lambs. Technical bulletin, Agricultural Research Institute, Cyprus. (87): 5pp.


Nut

In Vit

FL

In Vit

No Oral

FL

FL

Nut

Food

Mineral

Prim

Prim

Abstract

Abstract


Eco-SSL for Manganese  


Drug Evdokimov, P. D., Volokhova, E. S., and Razbitskii, V. M. 1979. effect of sulfadimethoxine and trace elements on the level of group b vitamins.  


J Nutr. 68:49-56,1959

Nut def Everson, Gladys J. 1970. effects of manganese deficiency during gestation of the offspring.  


Bull Environ Contam Toxicol; 14 (3). 1975 370-373


Ferket, P. R. Lohmann und Co. AG Cuxhaven Germany. 1997. [optimization of turkey feeding in view of health and performance]. <original> optimierung der putenfuetterung im hinblick auf gesundheit und leistung. *Lohmann Information.* (No.1) P. 17-24


No Tox  Furmaga, S. and Gundlach, J. L.  1978.  the behaviour of certain mineral elements in the sera of calves in the course of the experimental invasion due to fasciola hepatica.  21.


Genlin, W., Yuanxin, W., Quanhai, Y., and Maochang, H. Nanjing Agricultural Univ. China. 1996. concentrations of protein, glucose, fructose and ions in the flushings of the oviducts and uteri of erhualian and meishan sows. *Reproduction in Domestic Animals. V.* 31(4-5) P. 623-627


CP  Gilani, S. H. and Alibai, Y. 1985. the effects of heavy metals on the chick embryo development. American Association of Anatomists 98th Annual Meeting and the Association Canadienne Des Anatomistes (Canadian Association of Anatomists) 29th Annual Meeting


Bio Acc  Gochfeld, M. UMDNJ-Robert Wood Johnson Medical School Piscataway NJ. spatial patterns in a bioindicator: heavy metal and selenium.  *Arch Environ Contam Toxicol.*  V33, N1, P63(8)


Diss  Goetz, G. 1985. *Animal Experiments in Order to Determine the Effects of Cd on Parameters of the Reticuloendothelial and Hematopoietic System and on the Distribution of Essential Metals in Different Organs.* <NOTE> Diss. (Dr.Rer.Nat. NP-8770267


No COC  Grandhi, R. R. and Ibrahim, E. A.  1990.  changes in apparent absorption and retention of nutrients during gestation in gilts fed two dietary calcium and phosphorus levels.  CAN J ANIM SCI.  


FL  Grigor'eva, T. E. and Ivanov, G. I.  1996.  prophylaxis of alimentary infertility in cows.  <original> profilaktika alimentarnogo besplodiya korov.  Veterinariya.  (No.3) P. 41-45


Nut


Abstract


No Oral

Gruden, N. suppression of transduodenal manganese transport by milk dietsupplemented with iron.

Not Avail


Bio Acc


No Dur


No COC


Nut def


Nut


Acu


No COC


Prim


Nut def


Phys


FL


Nut def


Abstract


No Oral


Surv


Diss


Unrel


Bio Acc

Hall, J. O. 1990. elevated metal content in water as a cause of chronic illness poorreproduction, and poor milk production. 52.

No Dose


No Control


Nut


Plant


Nut


HHE


Mix


Alt

Han, J. 1975. *Control of Lethal Arrhythmias Associated With Coronary Heart Disease. Experimental Studies of Arrhythmias in Relation to Coronary Heart Disease.* &lt;NOTE&gt; Rept. for Jul 72-Jun 75. NIH-N01-HV-22974-A75


No Tox  Hidiroglou, M. and Shearer, D. A. concentration of manganese in the tissues of cycling and anestrous ewes.


Hill, R. 135(1) 1-16. a review of the 'toxic' effects of rapeseed meals with observations on meal from improved varieties. *BR. VET. J.* 1979


Hlasny, J. Vyzkumny Ustav pro Chov Skotu Rapotin Czech Republic. 1998. [rational use of mineral-vitamin premixes in cattle, especially in dairy cows]. <original> racionalni vyuzyti mineralne-vitaminovych smesi u skotu, zejmena u dojnic. *Vyzkum v Chovu Skotu.* V. 142(2) P. 26-32


Hoehler, D. 1992. [investigations on the effect of a corn-soybean diet supplemented with citric and fumaric acid on the utilization of zinc as well as of other minerals in the piglet]. <original>untersuchungen zum einfluss einer zulage an citronen- und fumarsaeure zu einer mais-soja-diaet auf die verwertung von zink sowie weiterer mineralstoffe beim ferkel. 183 P.


Holder, D. P. 1977. the effect of dietary calcium and manganese levels on egg shell quality. Poultry Science. 56 (5). 1977 1723


In Vit

Bio Acc

Bio Acc

Bio Acc

Bio Acc

Bio Acc
Honda, Katsuhisa Ehime Univ Japan, Min, Byung Yoon, and Tatsukawa, Ryo. heavy metal distribution in organs and tissues of the eastern great. *Bull Environ Contam Toxicol.* V35, N6, P781(9)

In Vit

No COC

Bio Acc

No Oral

CP

FL
Hossain, S. M. and Rezende, M. J. M. 1996. effect of several levels of manganese and available phosphorus on egg production and egg shell quality. <original> efeito de varios niveis de manganes e fosforo disponivel sobre a producao e qualidade de ovos em poedeiras. *Arquivo Brasileiro De Medicina Veterinaria e Zootecnia. V.* 48(5) P. 567-573

FL


Hu Shoule and Liu Fanping. 1990. Effect of dietary calcium and manganese levels on the growth performances of muscovy ducks (cairina moschata). *Journal of Fujian Agricultural College.* V. 19(1) P. 64-70


Unrel Husain, R., Seth, P. K., and Chandra, S. V. early inhibition of succinic dehydrogenase ec-1.3.99.1 by manganese in rat gonads. Bulletin of Environmental Contamination and Toxicology. 16 (1). 1976 118-121


FL  Hussein, S. A., Azab, M. E(A), and Abdel-Maksoud, H.  1999.  metabolic changes concerning the effect of castration on some blood constituents in male rabbits.  *DTW (Deutsche Tiereraerztliche Wochenschrift)*  106(3): 113-118.


Mineral  Hvidsten, H. and Lund, S. Norges Landbrukshoegskole Aas Norway Inst. for Husdyrfag.  1988.  the effect of four dietary levels of calcium, adjusted by limestone meal, on feed consumption, production, egg quality and fat and mineral retention in laying hens  also incl. egg shell, egg albumen, egg yolks.  *Norwegian Journal of Agricultural Sciences. V. 2(2) P. 141-149*


Diss  Ibrahim, A. H. M. E.  1985.  ultimobranchial gland in relation to age and egg laying cycle in chickens [egypt].  88 P.


---

*Eco-SSL for Manganese*  133  April 2007


activities of $\text{Fe(III)}(3,5\text{-diisopropylsalicylate})$-$3$ and $\text{Mn(III)}$-$2\text{(mu-3-o)(3,5\text{-diisopropylsalicylate})}$-$6$. *Inflammopharmacology* 4(4): 309-321.

**Meth**

**Meth**

**Bio Acc**

**Unrel**

**CP**

**Mineral**

**Phys**

**FL**

**No Oral**

**Mix**

**Mix**

**Bio Acc**

**No COC**

**No COC**


FL Jilg, T. Staatliche Lehr und Versuchsanstalt fuer Viehhaltung und Gruenlandwirtschaft Aulendorf Germany. 1992. [nutritive value and feed intake by growing cattle of the regrowth of extensively used sites in baden-wuerttemberg]. <original> futterwert und futterakzeptanz von aufwuechsen extensiv genutzer standorte in baden-wuerttemberg bei wachsenden rindern. [ecological aspects of extensive land management]. <original> oekologische aspekte extensiver landbewirtschaftung. P. 443-446. No. 35

FL Jilg, T. Staatliche Lehr und Versuchsanstalt fuer Viehhaltung und Gruenlandwirtschaft Aulendorf Germany and Briemle, G. 1993. feeding value and acceptance of grass from extensively used grassland for growing heifers. <original> futterwert und futterakzeptanz von aufwuechsen aus
extensiv genutztem gruenland bei wachsenden rindern.  

In Vit  


In Vit  


Phys  


Mix  


FL  


No Dose  

Joardar, M. and Sharma, A.  1990.  comparison of clastogenicity of inorganic mn administered in cationic and anionic forms in vivo.  

Mutat.Res.  240:  159-163.

Bio Acc  


Unrel  


No Oral  

John Mathias, Gumbinger Hans Gerd(A), and Winterhoff Hilke.  1993.  the oxidation of caffeic acid derivatives as model reaction for the formation of potent gonadotropin inhibitors in plant extracts.  


CP  


P. 12.1-12.25

Abstract  


Federation Proceedings  44:  752.

Nut  


HHE  


CP  


Jukes, T. H. 1977 2514-2518


**FL**


**FL**


**FL**


**Mix**


**FL**


**FL**


**Unrel**


**Nut def**


**FL**


**In Vit**


**Mineral**


**Nut**


**FL**


Mineral


Mineral


Bio Acc


Mineral


Plant


Alt


FL


FL


No COC

Kaloyanova, F. and Ivanova-Chemishanska, L. 1989. dose effect relationship for some specific effects of dithiocarbamates. *Journal of Hygiene, Epidemiology, Microbiology, and Immunology* 33(1)

FL


Surv


Rev


Surv


Meth


**Diss**

**HHE**

**Mineral**

**Unrel**

**In Vit**

**FL**

**No Oral**

**No Oral**

**Alt**

**Unrel**

**Alt**

**In Vit**

**Phys**

**Nut def**


Diss  Kelly, W. A.  1971. investigations of the responses of rats to diets containing multipesticide components when copper and manganese were fed at deficient, marginal and excess concentrations.  *Diss. Abstr. Int.;* 32(2): 1045B-1046B; 1971

Mix  Kelly, William Alva.  1971.*Responses of Rats to Diets Containing Multipesticide Components When Copper and Manganese Were Fed at Deficient, Marginal, and Excess Concentrations*


---

*Eco-SSL for Manganese*  147  April 2007
Alt


In Vit


Abstract


FL


No Tox


Nut


Unrel


FL


FL


Mineral


Mineral

Khalili, M., Lindgren, E. Swedish Univ. of Agricultural Sciences Kungsangen Research Station Uppsala Sweden, Varvikko, T. ILCA Addis Ababa Ethiopia, and Varvikko, T. comp. 1991. a survey of mineral status of soil, feeds and cattle in the selale ethiopian highlands: ii. trace elements. development of appropriate feeding systems for dairy cattle in the ethiopian highlands. research and development project in collaboration between international centre for africa (ilca) and ministry of agriculture, ethiopia. funded by the finnish international development agency - finnida. final report. 14 P.

Mineral

Khalili, M., Lindgren, E. Swedish Univ. of Agricultural Sciences Kungsangen Sweden, Varvikko, T. ILCA Addis Ababa Ethiopia, and Varvikko, T. comp. 1991. a survey of mineral status of soils, feeds and cattle in the selale ethiopian highlands: i. macro elements. development of appropriate feeding systems for dairy cattle in the ethiopian highlands. research and development project in collaboration between international livestock centre for africa (ilca) and ministry of agriculture, ethiopia. funded by the finnish international development agency finnida. final report. 17 P.


Kienzle, E. Tierarztliche Hochschule Hannover Germany F. R. Inst. fuer Tierernaehrung. 1988. [the trace element requirements of the dog]. <original> spurenelementbedarf des hundes. Uebersichten Zur Tierernaehrung. V. 16(2) P. 153-212


Kim, Hee Ju, Moon, Hyung Ro, Earm, Yung E, and Ho, Won Kyung. 1988. sodium(+)calcium(2+) exchange system in atrial trabeculae and vascular smooth muscle of the rabbit. Taehan Saengri Hakhoechi (1988) 22(1):.


Kirchgessner, M., Maier, R., and Reichlmayr-Lais, Anna M. 1984. concentration of iron, copper, zinc, manganese, cobalt and magnesium in various organs and tissues resulting from different nickel supply.  Z. Tierphysiol. Tierernahrung Futtermittelkd. 52(4-5): 217-27.


Surv Kishida, Y. Okayama Univ. Japan Faculty of Agriculture, Okabe, T., and Inoue, R. 1991. mineral concentration in water on the livestock farm on hilly land [in japan]. *Scientific Reports of the Faculty of Agriculture - Okayama University*. (No.78) P. 35-39


In Vit

Nut def

Surv

Alt

No Dose

FL

FL

Surv

FL

Mix

FL

FL

FL

FL

No COC  Kolomiitseva, M. G., Voznesenskaya, F. M., Isayeva, E. A., and Generalov, A. A. 1972. role of ultraviolet radiation in increasing natural resistance of the animal organism when associated with different amounts of copper and manganese in the daily ration. Journal of Hygiene, Epidemiology, Microbiology, and Immunology 16(2).


Konstantinova, S. G. and Russanov, E. M. 1994. liver superoxide dismutases after copper deficiency and/or indomethacin treatment of rats.  

Research in Veterinary Science. V. 45(3) P. 287-290

Kontur, Paul Joseph. 1984. manganese toxicity in the developing rat brain: the involvement of monoamine systems. 

Korc, M. and Brannon, P. M. regulation of pancreatic exocrine function by manganese. 
Trace Elements In Man And Animals 6 / Edited By Lucille S. Hurley, ... [Et Al.]. p. 43-47.

Korcak, R. F. 1989. adaptability of blueberry species to various soil types: iii. final growth and tissue analyses. 


Kornegay, E. T., Thomas, H. R., and Bartlett, H. S. 1981. phosphorus in swine. 3. influence of dietary calcium and phosphorus levels and growth rate on mineral content of hair from gilts and barrows or boars. 

Korol W(A), Wojcik S(A), Matyka S(A), and Hansen, T. S. 1996. availability of manganese from different manganese oxides and their effect on performance of broiler chickens. 


Korolev, A. A. and Modenova, O. A. 1991. [an evaluation of the toxicity of manganese and iron in their separate and joint body uptake]. <original> otsenka toksichnosti margantsa i zheleza pri razdel'nom i sovmestnom postuplenii v organizm. 

Korynta, E. D. and Johnson, P. E. the effects of animal protein on absorption and metabolism of manganese in the rat. 


FL  Kosla, T. 1987. the level of iron manganese and cobalt in the soil grass and in young bulls in the areas irrigated with waste water.  *Pol Arch Weter.* 24(4): 587-596.


Eco-SSL for Manganese

No Oral


Mix


Fate


FL


Unrel


FL


In Vit


FL


FL


FL


FL


Nut def


Nut def


CP

Kralik, A. Technische Univ. Muenchen Freising Germany Inst. fuer Ernaehrungsphysiologie, Eder, K., Kirchgessner, M., and Giesecke, D. 1995. influence of the depletion of iron, copper, zinc and manganese on serum concentrations of t3 and t4 and activity of hepatic deiodinase. <original> einfluss einer defizitaren versorgung der spurenelemente eisen, kupfer, zink und mangan auf die konzentrationen von t3 und t4 im serum und die aktivitaet der dejodase in leber. proceedings of the
society of nutrition physiology. <original> berichte der gesellschaft fuer ernahrunghsphysiologie. P. 84. V. 4

Nut

No COC

FL

Unrel

Mix

FL

Rev

Mineral

Nut

No Dose

FL

No Dose

FL

FL


<table>
<thead>
<tr>
<th>Type</th>
<th>Author(s)</th>
<th>Title and Details</th>
</tr>
</thead>
</table>
Drug


FL


L’Herroux, L., Roux, S. le, Appriou, P., and Martinez, J. 1997. behaviour of metals following intensive pig slurry applications to a natural field treatment process in brittany (france). *Environmental Pollution. V. 97(1/2) P. 119-130*

---

*Eco-SSL for Manganese* 164 April 2007


Surv LaDelfe, C. M. 1981. *Detailed Geochemical Survey Data Release for the San Andres-Oscura Mountains Special Study Area, New Mexico.* GJBX-215-81; LA-8016-MS


Eco-SSL for Manganese  

166  

April 2007


Laskavaya, a. I. 1970. (the available reserves and histological structure of the adrenal cortex with the administration of manganese chloride.). Endokrinopatti Lech Gorm Resp Mezhved SB; (5). 1970 94-98

**Abstract**


**Nut**


**Bio Acc**


**Acu**


**No Oral**


**Abstract**


**CP**


**CP**


**In Vit**


**CP**


**In Vit**


**No COC**

Carcin

Drug

Phys

Rev

In Vit

Nut def

Nut def

HHE

FL

CP

FL

In Vit

Drug

FL

Surv


Aquatic Lien, V. 1978. *Investigating the Marine Environment and Its Resources. Part II. TAMU/SG-79/401-2; NOAA-78103108*


FL Lipnitskii, S. S. and Dovnar, N. I. 1976. the effect of trivitamine and micro-elements on some physiologicalindices of calves and on their susceptibility to parasiticinfections. <document
Mix

Mineral

FL

In Vit

In Vit

Unrel

Phys

Unrel

No Oral

FL

Nut

Bio Acc

No COC


Luk'ianova, E. M., Mel'nichuk, D. A., Skorik, L. V., Rodionov, V. P., and Omel'chenko, L. I. 1980. [Effect of vitamin D3 and carboestimulin on the content of carbohydrate metabolism substrates and the tricarboxylic acid cycle in liver of rats with experimental rachitis]. *<original> Vliaienie vitamina d3 i karboestimulina na socerzhanie substratov uglevodnogo obmena i tsikla trikarbovykh kislot v...

**Drug**


**FL**


**FL**


**FL**


**No Oral**


**FL**


**FL**


**FL**


**FL**

Luo, Xugang, Su Qi, and Huang Junchun. 1991. the effects of manganese (mn) deficiency and excess in a practical diet on contents of other minerals and trace elements in tissues of broiler chicks. *Animal Husbandry and Veterinary Medicine. V. 23(4) P. 146-147*

**FL**

Luo Xugang and Su Qi. 1991. effects of various levels of dietary manganese on growth, incidence of leg abnormality, some plasma biochemical criteria and immunological parameters in broiler chicks. *Chinese Journal of Animal Science. V. 27(1) P. 11-14*

**FL**

Luo Xugang. 1991. effects of different levels of manganese on tissue mineral concentrations of broiler chicks fed a practical diet. *Acta Zoonutrimenta Sinica. V. 3(1) P. 17-20*

**Nut def**


**FL**


**Unrel**


MacNeil, J. D., Patterson, J. R., Salisbury, C. D. C., and Tessaro, S. V. 1990. An investigation of the trace element status of bison in wood buffalonational park and of ranch-raised bison in...


**Abstract** Magour, S., Maeser, H., and Steffen, I. 1985. differential effects of manganese on rna-polymerases i and ii in rat Brain. *26th Spring Meeting of the Deutsche Pharmakologische Gesellschaft (German Pharmacological Society)*


Alt  Malecki, E. A. factors affecting manganese toxicity.  *Crisp Data Base National Institutes Of Health*


Malinee Limpoka, Samutra Sirivejapandu, and Prapant Kessank. 1983. research on mineral element problems in dairy cattle. *<original> kan suksa panha khong rae that thi kieo khong kap kan phasom tit yak nai khonom. research report 1983. <original> rai ngan khon khwa wichai pracham pi 2526. P. 139-140*


FL

Surv

FL

Unrel

In Vit

Prim

No Tox

In Vit

No Dose

Not Avail

No COC

Plant

Abstract

Nut
manganese intake on body, wool and testicular growth of young rams and on the concentration of manganese and the activity of manganese enzymes in tissues [sheep].  *Australian Journal of Agricultural Research.  V. 39(2) P. 517-524*

**Org Met**


**Nut**


**Nut def**


**Nut def**


**Nut def**


**Surv**


**No COC**


**Nut**


**Rev**


**CP**


**No COC**


**In Vit**


**No Oral**


Mcdowell, L. R. 24618. iron manganese and zinc. MCDOWELL


Mcguinness Orla M(A), Moreton Roger B, Johnson Martin H, and Berridge Michael J. 1996. a direct measurement of increased divalent cation influx in fertilised mouse oocytes. Development (Cambridge) 122(7): 2199-2206.


Mel'chenko, A. I. 1972. concentration of some trace nutrients (copper, manganese, cobalt) in the liver of broiler chicks during the incorporation of different phosphorus additives into the ration. *Timiryazev. Sel'Skokhoz. Akad :* No. 185, 143-6.


Menton, K. and Markham, A. 1996. the ability of spermine to reduce the protective action of cyclosporin a with rat hepatic mitochondria. *British Journal of Pharmacology* 119(PROC. SUPPL.): 270P.


**Eco-SSL for Manganese** 191  April 2007


FL  Molodtsov, G. P. 1986.  improving the system of feeding pigs on farms in far eastern regions ofthe USSR.  <document title>sovshernstvovanie tehnologii kormleniyasel'skokhozyaistvennykh zhivotnykh.  52-58.


---

Eco-SSL for Manganese  April 2007  193

Bio Acc Morena, M. Universitat Automona de Barcelona Bellaterra Spain, Sanpera, C., Crespo, S., Jover, L., and Ruiz, X. inter- and intraclutch variability in heavy metals and selenium levels. *Arch Environ Contam Toxicol. V33, N1, P71(5)*


In Vit Morera, M. Universitat Automona de Barcelona Bellaterra Spain, Sanpera, C., Crespo, S., Jover, L., and Ruiz, X. inter- and intraclutch variability in heavy metals and selenium levels. *Arch Environ Contam Toxicol. V33, N1, P71(5)*

FL Moroz, I. G. and Leskov, A. A. 1995. effect of micronutrients on number of fetuses and milk performance in sows. *Veterinariya. (No.7) P. 17-18*


Abstract Morris, E. R. and Ellis, R. 1976. relation of the chemical form of iron and zinc phytates to the biological availability of iron and zinc to rats. *Federation Proceedings. 35 (3). 1976 683*


Fate Mostafchiev Dimitar, Sirakov Ljuben(A), and Bontchev Panayot. 1998. the competition between transferrins labeled with !5!9fe, !6!5zn, and !5!4mn for the binding sites on lactating mouse mammary gland cells. *Biological Trace Element Research* 61(2): 181-191.
Moutafchiev Dimiter A(A) and Sirakov Ljuben M. 1992. competition of manganese and zinc with iron-59 and iron-59 for the plasma membrane receptors from lactating mouse mammary gland. *Biological Trace Element Research* 35(3): 203-211.


Nakaue, H. S. National Technical Information Service (NTIS). Nutrition as related to water quality and pollution. *Fedrip Database*


CP Neal, R. H. Ministry of Agriculture and Lands Belize, Neal, R. H., and Awe, E. A. Ministry of Natural Resources Belmopan Belize Agricultural Library and Information Centre eds. 1981. a comparison of the nutrient levels of various pasture grasses and legumes as related to soil type and fertility - interim report. proceedings of the second agricultural research and development symposium. P. 63-73


CP Newland, M. C. 1988. accumulation of manganese in globus pallidus and effects on motor function. *Ninety-sixth Annual Convention of the American Psychological Association*


---

**Eco-SSL for Manganese** 202  April 2007


FL  Novakova, S. and Dinoeva, S.  the effect of hexavalent chromium and manganese on experimental atherosclerosis.  GIG SANIT; (4). 1977 72-74


FL  Novikov, G. V. and Zakirnichnaya, G. A.  1970.  [level of protein-bound iodine of the blood serum in animals maintained on natural and synthetic diets].  <original> Uroven' belkovosviazannogo ioda
syvorotki krovi zhivotnykh pri soderzhaniy ikh na estestvennom i sinteticheskom ratsionakh.  

**Nut**  

**No COC**  

**Mineral**  

**Nut**  

**Nut**  

**Nut def**  

**Unrel**  

**No COC**  

**Nut def**  

**Nut**  
Obsioma, A. R.  1992.  some reproductive problems in philippine carabaos and improvement of conception rate by mineral-concentrate supplementation.  _139 Leaves_

**FL**  

**FL**  

**FL**  


Oliver, J. W. interrelationships between athyreotic and manganese-deficient statesrats. (5) PG-p.597-600


FL  Oresnik, A. Biotechnical Faculty Ljubljana Slovenia Zootechnical Dept. 1994. manganese in forage and in dairy cattle nutrition. <original> vsebnost mangana v krmi in njegov pomen v prehrani krav molznic. Sodobno Kmetijstvo. V. 27(10) P. 420-425


Abstract  Ozawa, H., Akabane, S., Watanabe, K., and Hashimoto, K.  1979.  the relationship between mortality of stroke and trace metal elements.  *6th Symposium on Environmental Pollutants and Toxicology*


Unrel Parker, C. 1976. role of the genetics and physiology of bordetella pertussis in the production of vaccine and the study of host-parasite relationships in pertussis. *Advances in Applied Microbiology* 20: 27-42.


In Vit

Mineral

Drug

Mineral

Nut def

Bio Acc

No Oral

CP

Phys

FL

Mix

Rev

CP


Qi Zhouyue, Han Bin, and Hou Jiangwen (Shaanxi Provincial Inst. of Animal Husbandry and Veterinary Medicine, Xianyang China. 1986. an investigation on manganese deficiency in ducklings. *Chinese Journal of Veterinary Science and Technology. (No.4) P. 3-5*


<table>
<thead>
<tr>
<th>Type</th>
<th>Reference</th>
</tr>
</thead>
</table>
Fate

Bio Acc

Nut

Bio Acc

Bio Acc

Bio Acc

Bio Acc

Nut

Bio Acc

Bio Acc

Bio Acc

Bio Acc

Bio Acc

Bio Acc

Bio Acc

Bio Acc

Bio Acc

Bio Acc

Bio Acc
Diss

In Vit

No COC

Plant

No Dose

In Vit

No COC

Unrel

Mineral

FL

Nut def

Bio Acc

No Oral

Meth

Drug


FL Rozputniy, O. I. Bila Tserkva State Agricultural Univ. Ukraine. 1998. [assessment of admitting heavy metals to organism of young animals of cattle over a period of growing and feeding]. <original>otsinka nadkhodzhennya vazhkykh metaliv v organizm molodyaka velykoi rohatyi khudoby za period vyroshchvannya u vidhodivli. *Visnyk Agrarnoyi Nauky. (No.7) P. 39-41


Rutjawate Taharnklaew, Wipha Wiphamaneeroj, and Peerasak Chantara-prateep (Chulalongkorn Univ., Bangkok Thailand Faculty of Veterinary Science. 1985. Infertility problems in dairy cattle in phra nakhon si ayuthaya province [thailand]. *Journal of the Thai Veterinary Medical Association Under Royal Patronage.* V. 36(3) P. 243-268

---

*Eco-SSL for Manganese* 228  April 2007


Sakamoto, A. 1966. manganese and hydralazine as studied by neutron activation and radioactive mn. *Proceedings of the Society for Experimental Biology and Medicine; 123*


Salii, N. S. 1966. effect of food rations with different manganese content on the vitamin a accumulation and the ceruloplasmin activity in the animal body. *Gig. Sanit.* (1966) 31(12): 27-30

---

**Eco-SSL for Manganese** 231 April 2007


Samara, H. M., Robbins, K. R(A), and Smith, M. O. 1996. environmental heat stress does not reduce blood ionized calcium concentration in hens acclimated to elevated temperatures. *Poultry Science 75(2): 197-200.*


Sanhueza F, Javier. 1991. [determination of the serum levels of calcium, phosphorus, manganese, zinc and copper at peripartum in holstein friesian cows in los angeles zone]. <original>
determinacion de los niveles sericos de calcio, fosforo, manganeso, zinc y cobre en el periparto de vacas holstein friesian en la zona de los angeles. 62 P.


In Vit
Sasaki Junzo(A), Sato Eisuke F, Nomura Takako, Mori Hideki, Watanabe Sadahiro, Kanda Shigeto,
Watanabe Hiroki, Utsumi Kozo, and Inoue Masayasu. 1994. detection of manganese superoxide
dismutase mrna in the theca interna cells of rat ovary during the ovulatory process by in situ

Bio Acc
composition of the hoof shoe of thoroughbred and cold-blooded horses entered in the polish

FL
Sasimowski, W., Budzynski, M., Lipecka, C., Moczybroda, J., and Kapron, M. Akademia Rolnicza
Lublin Poland Inst. Hodowli i Technologii Produkcji Zwierzecej. 1987. chemical composition of
hoof shoe of warm- and cold-blooded horses entered the polish stud books. <original> skład
chemiczny puszki kopytowej koni szlachetnych i zimnowodnych zapisanych do polskich ksiąg
stadoowych.  Roczniki Nauk Rolniczych. Seria B - Zootechniczna. <Subtitle>Polish Agricultural
Annual. Series B - Animal Science. V. 103(1) P. 131-147

No Control
Sasmal, N., Mukherjee, Dipti, Kar, Nirmal C., and Chatterjee, Gora C. 1968. effect of manganese

No Dose

Fate
Sato, I., Matsusaka, N., Kobayashi, H., and Nishimura, Y. 1996. effects of dietary manganese

No Oral
Sato Itaru(A), Matsusaka Naonori(A), Nishimura Yoshikazu, Shinagawa Kunihiro(A), and
Kobayashi Haruo(A). 1993. availability of zeolite as an eliminator for the incorporated
radionuclides: effect on the biological half-life of manganese-54 and zinc-65.  Radioisotopes

Fate
Sato Itaru(A), Yoneta Takako(A), Matsusaka Naonori(A), Kobayashi Haruo= (A), Tsuda Shuji(A),
and Nishimura Yoshikazu . 1996. distributions of 54mn and 65zn in mouse fetuses.  Radioisotopes
45(12): 774-779.

In Vit
1986. mechanism of manganese-induced contraction in ileal longitudinal muscle of guinea - pig.

Unrel
dismutase in rat stomach: application of triton x-100 and suppression of endogenous streptavidin

In Vit
Sauer, Glenn R., Adkisson, H. D., Genge, B. R., and Wuthier, R. E. 1989. regulatory effect of
endogenous zinc and inhibitory action of toxic metal ions in calcium accumulation by matrix

In Vit
Savage, A. O. and Atanga, K. G. 1988. caffeine-induced and potassium-induced contractures of


Abstract  Scheideler, S. E(A), Ceylan, N., Novak C(A), Puthponsiriporn U(A), and Sefton, T. 1999. supplemental manganese (mn) and zinc (zn) from inorganic and organic measurements. *Poultry Science* 78(SUPPL. 1): 70-71.


jodversorgung, 2: status des fe, mn, cu und zn sowie weitere biochemische parameter. [macro and trace elements]. <original> mengen- und spurenelemente.  P. 510-516

**Not Avail**

**No COC**

**No COC**

**HHE**

**Unrel**

**Bio Acc**

**Mix**

**No COC**

**HHE**
Schroeder, H. A. and Tipton, I. H.  965-1978.  the human body burden of lead.  *Arch. Environ. Health; 17(6)*

**In Vit**

**Unrel**

**FL**

**FL**

**FL**


Shan Anshan . 1990. several non-ration factors related to content of manganese and iron in chicken feather. *Animal Husbandry and Veterinary Medicine.* V. 22(1) P. 13-14


Unrel  Shine, K. I. and Langer, G. A.  control of ion movement by cardiac sarcolemma.  *Recent Advances in Studies on Cardiac Structure and Metabolism*


---

**Eco-SSL for Manganese** 241  April 2007


FL Simek, M. 1995. recommended requirements of mineral substances and their resources in cattle and sheep: doporučene potreby mineralnich latek a jejich zdroje u skotu a ovcí.


Singh, Jaswant Industrial Toxicology Research Centre India and Kaw, Zaidi S. H. early biochemical response of pulmonary tissue to manganese dioxide. *Toxicol. V8, N2, P177(8)*


In Vit  Skreb, Yvette and Simeon, Vladimir. 1987. metal antagonism in cadmium(ii)/zinc(ii) and manganese(ii)/nickel(ii) treatments of cultured chinese hamster fibroblasts.  

19th Annual Meeting of the Society for Neuroscience

In Vit  Sloot, W. N. and Gramsbergen J-B, P. 1994. axonal transport of manganese and its relevance to selective neurotoxicity in the rat basal ganglia.  


No Oral  Slutsky, Robert A., Peterson, Thomas, Strich, Gideon, and Brown, Jeffrey J. 1985. hemodynamic effects of rapid and slow infusions of manganese chloride and gadolinium-dtpa in dogs.  
Radiology (Easton Pa.) 154(3): 733-5.

Systematic And Applied Microbiology 11(1): 75-84.

Phys  Smalheiser, N. R. 1990. cell attachment and neurite stability in ng 108-15 cells effects of 5' deoxy 5' methyl thiadenosine mta compared with laminin kinase inhibitor h-7 and manganese ions.  


Nut def  Smart, M. E. 1985. nutritional factors of lameness and metabolic bone disease in cattle.  


Plant  Smirmova, Z. A. 1970. use of trace nutrients to increase the growth of plants and the soil germination rate of seeds of some introduced varieties.  

Diss  Smith A. 1986. aspects of seasonal breeding in the male blue fox (alopex lagopus) some testicular parameters and plasma hormone concentrations.  

Unrel  Smith, A., Bugge, H. P., Berg, K. A., Moller, O., and Hansson, V. 1986. seasonal changes in testicular structure and function in the blue fox alopex-lagopus as quantified by morphometric analysis and measurement of adenylate cyclase activity.  


| Mix | Spivey, Fox M. R. FDA, Jacobs, R. M., Jones, A. O. Lee, and Fry, Bert E. | effects of nutritional factors on metabolism of dietary cadmium at | *Environ Health Perspec.* V28, P107(8) |
| FL | Spoerl, R. and Kirchgessner, M. 205. | increased storage of iron, zinc, manganese and nickel in pregnancy. | *Zeitschrift Fur Tierphysiologie Tierernahrung Und Futtermittelkunde* |


In Vit  Stefanovic, Vladisav, Savic, Vojin, Vlahovic, Predrag, Ardaillou, Nicole, and Ardaillou, Raymond.  1989.  ecto-


CP  Suchat Chuenprasert, Pornchai Chamnampood, and Aroon Noomtoom (Northern Veterinary Diagnostic Centre, Lampang Thailand.  1983. study of mineral level in dairy cows in the northern part of thailand. <original> kan suksa radap raethat nai khonom thap phaknua khong prathet thai. proceeding of the 10th annual veterinary conference. <original> pramuan ruang prachum wichakan thang sattawahaphet khrang thi 10 prachampi 2526 .  P. 69-77


Sunanta Pongsamart, Surang Assawamunkong, and Naranin Markman (Chulalongkorn Univ., Bangkok Thailand. 1986. biochemical and biological evaluation of nutritional quality of mushrooms. *132 Leaves*


Suttle, N. F. 1979. copper, iron, manganese and zinc concentrations in the carcases of lambs and calves and the relationship to trace element requirements for growth. *British Journal of Nutrition* VO-42: 89-96


Swarup, G., Subrahmanyam, G., and Rema, V. 1988. Purification and characterization of a tyrosine-specific protein kinase of Mr 60,000 and comparison with a kinase of Mr 56,000 from rat spleen. *Biochemical Journal* 251(2): 569-76.


Alt

Phys

Mix

Plant

Mineral

No COC

CP

No COC

In Vit

No Dose

FL

Surv

FL


Meth


HHE


No COC


Acu


CP


Mineral


Diss

Timarchi Melendez, V. F. 1992. [determination of the utilization of manganese dioxide in growing chickens]. <original> determinacion de la utilizacion del manganeso del dioxido en pollos en crecimiento. 81 P.

In Vit


In Vit


Phys


FL


Drug


FL


FL


Tokosova, M. Vojensky Veterinarny Doskolovaci Vyskumnny Ustav Kosice Czechoslovakia. 1989. the effect of growth promoters on the contents of microelements in the organism of chicks. <original> vplyv stimulatorov rastu na obsah niektorych mikroprvkov v organizme kurciat. Veterinarni Medicina - UVTIZ. V. 34(2) P. 107-111


Unrel


CP


CP


CP


FL


No COC


Drug


Diss

Treuthardt, J. 1992. Hematology, Antioxidative Trace Elements, the Related Enzyme Activities and Vitamin E in Growing Mink on Normal and Anemiogenic Fish Feeding

CP

Triggle, C. R., Fodor, G., Pfeiffer, C. J., and Scott, T. M. 1952. the interaction of cadmium manganese zinc and lead with calcium dependent physiological processes and the possible implications in cardio vascular and cerebro vascular diseases. BURFORD

Surv


Meth


FL


Surv


Tsunobuchi-Ushijima Hiromi(A) and Gomi Yasuo. 1997. effects of phorbol-12,13-dibutyrate and protein kinase c inhibitors on mn-2+-dependent norepinephrine-induced contractions involving increase in mn-2+ sensitivity in ca-2+-depleted vas deferens of the guinea pig. *General Pharmacology* 29(4): 591-595.


No Oral  Valois, A. A. and Webster, W. S.  1989. retention and distribution of manganese in the mouse brain following acute exposure on postnatal day 0 7 14 or 42 an autoradiographic and gamma counting study.  Toxicology; 57 (3). 1989. 315-328.


FL  Vandergrift, B. Manna pro Corporation Perry GA USA. 1993. mineral proteinates in the animal feed industry.  *Kraftfutter.*  (No.11) P. 548-552


FL Vojtisek, B., Hamrik, J., Hronova, B., Docekalo, H., and Diblikova, I. Vyzkumny U. 1990. The effect of dry period in cows in a herd with the obesity syndrome on selected metabolism parameters of the cows and on the health of the calves. <original> vliv doby stani nasucho krav ve stade s vyskytem syndromu obezity na vybrane ukazatele jejich metabolismu a stav u telat.  *Veterinarni Medicina - UVTIZ. V.* 35(9) P. 513-521


---

**Eco-SSL for Manganese** 273  April 2007
Drug

Nut def

FL

FL

FL

FL

FL

Unrel

FL

Mix

No Oral

Nut

Rev

---

**Eco-SSL for Manganese** 274 **April 2007**
zinc deficiency: effects on the distribution of nine elements (potassium, phosphorus, sodium,
magnesium, calcium, iron, zinc, copper and manganese) in regions of the rat brain.  *J. Nutr.*

diacylglycerol kinase from bovine testis: purification and properties.  *Journal of Biological
Chemistry*  269(33): 21155-21164.

In Vit  Walters, J. R. F. and Weiser, M. M.  1984.  characterization of the vitamin d dependent calcium
binding sites in rat intestinal golgi enriched membrane fractions.  *Biochemical Journal.*  218 (2).

fluorescence in a flame as a high-sensitivity detector for organomanganese and organotin
compounds following separation by high-performance liquid chromatography.  *Analytical


FL  Wang, A. and Shan, A. S.  1992.  effects of ca and zn on mineral content of serum, reproductive

FL  Wang An, Shan Anshan, and Yin Jiti (Northeast Agricultural Coll., Harbin China.  1990.  effect of
fibre and manganese on growth and manganese content in tissues of chicks.  *Heilongjiang Journal
of Animal Science and Veterinary Medicine.*  (No. 12) P. 1-3

on weight gain and mineral retention in tissues of growing-finishing pigs.  *Bulletin of Veterinary
College of PLA.*  V. 13(1) P. 83-88

manganese induced parkinsonism - an outbreak due to an unrepaired ventilation control-system in a


Phys  Wang, X., Yan, Y., and Li, Y.  1990.  effects of gsl on lipid regulation and antilipoperoxides.

No Tox  Wannemacher, R. W. Jr, Wannemacher, C. F., and Yatvin, M. B.  1971.  amino acid regulation of
synthesis of ribonucleic acid and protein in the liver of rats.  *Biochemical Journal*  124(2): 385-
92.

Meth  Wapnir, R. A.  1989.  protein digestion and the absorption of mineral elements.  *Advances in
Nut

Plant

Plant

Alt

Herp

Alt

Bact

In Vit

Nut

CP

Mineral

Surv

Diss

Abstract

Nut def

---

*Eco-SSL for Manganese* 276  April 2007


CP Weiss, B. 1973. *Long-Term Behavioral Consequences of Exposure to Drugs and Pollutants.* CONF-730678-1


No COC  WHO working group.  methyl isobutyl ketone.  *Environmental Health Criteria(117); 1990; 79 p*


CP

Yu, S. Beijing Inst. of Animal Science China and Masters, D. G. 1986. the availability of finely divided iron, zinc and manganese provided by intraruminal controlled release devices to sheep. [conference paper]. proceedings of the nutrition society of australia.  P. 131. V. 11

No Dose


FL


No COC


FL


FL


Drug


FL


FL


Mineral


Bio Acc


FL


Mineral


Nut

Eco-SSL for Manganese

No Dose

Drug

Abstract

FL

FL

Mineral

FL

Bio Acc

Mix

FL

FL

FL

FL

FL


<table>
<thead>
<tr>
<th>Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nut def</td>
<td>Zidenberg-cherr, S. and Keen, C. L. 1986. enhanced tissue lipid peroxidation a mechanism underlying pathologies associated with dietary manganese deficiency. <em>192ND American Chemical Society National Meeting</em></td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Rejection Criteria</th>
<th>Description</th>
<th>Receptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT (Abstract)</td>
<td>Abstracts of journal publications or conference presentations.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ACUTE STUDIES (Acu)</td>
<td>Single oral dose or exposure duration of three days or less.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>AIR POLLUTION (Air P)</td>
<td>Studies describing the results for air pollution studies.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ALTERED RECEPTOR (Alt)</td>
<td>Studies that describe the effects of the contaminant on surgically-altered or chemically-modified receptors (e.g., right nephrectomy, left renal artery ligation, hormone implant, etc.).</td>
<td>Wildlife</td>
</tr>
<tr>
<td>AQUATIC STUDIES (Aquatic)</td>
<td>Studies that investigate toxicity in aquatic organisms.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ANATOMICAL STUDIES (Anat)</td>
<td>Studies of anatomy. Instance where the contaminant is used in physical studies (e.g., silver nitrate staining for histology).</td>
<td>Wildlife</td>
</tr>
<tr>
<td>BACTERIA (Bact)</td>
<td>Studies on bacteria or susceptibility to bacterial infection.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>BIOACCUMULATION SURVEY (Bio Acc)</td>
<td>Studies reporting the measurement of the concentration of the contaminant in tissues.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>BIOLOGICAL PRODUCT (BioP)</td>
<td>Studies of biological toxicants, including venoms, fungal toxins, Bacillus thuringiensis, other plant, animal, or microbial extracts or toxins.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>BIOMARKER (Biom)</td>
<td>Studies reporting results for a biomarker having no reported association with an adverse effect and an exposure dose (or concentration).</td>
<td>Wildlife</td>
</tr>
<tr>
<td>CARCINOGENICITY STUDIES (Carcin)</td>
<td>Studies that report data only for carcinogenic endpoints such as tumor induction. Papers that report systemic toxicity data are retained for coding of appropriate endpoints.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>CHEMICAL METHODS (Chem Meth)</td>
<td>Studies reporting methods for determination of contaminants, purification of chemicals, etc. Studies describing the preparation and analysis of the contaminant in the tissues of the receptor.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>CONFERENCE PROCEEDINGS (CP)</td>
<td>Studies reported in conference and symposium proceedings.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>DEAD (Dead)</td>
<td>Studies reporting results for dead organisms. Studies reporting field mortalities with necropsy data where it is not possible to establish the dose to the organism.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>DISSERTATIONS (Diss)</td>
<td>Dissertations are excluded. However, dissertations are flagged for possible future use.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>DRUG (Drug)</td>
<td>Studies reporting results for testing of drug and therapeutic effects and side-effects. Therapeutic drugs include vitamins and minerals. Studies of some minerals may be included if there is potential for adverse effects.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>DUPLICATE DATA (Dup)</td>
<td>Studies reporting results that are duplicated in a separate publication. The publication with the earlier year is used.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>Rejection Criteria</td>
<td>Description</td>
<td>Receptor</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td><strong>ECOLOGICAL INTERACTIONS</strong> <em>(Ecol)</em></td>
<td>Studies of ecological processes that do not investigate effects of contaminant exposure (e.g., studies of “silver” fox natural history; studies on ferrets identified in iron search).</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>EFFLUENT</strong> <em>(Eff)</em></td>
<td>Studies reporting effects of effluent, sewage, or polluted runoff.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>ECOLOGICALLY RELEVANT ENDPOINT</strong> <em>(ERE)</em></td>
<td>Studies reporting a result for endpoints considered as ecologically relevant but is not used for deriving Eco-SSLs (e.g., behavior, mortality).</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>CONTAMINANT FATE/METABOLISM</strong> <em>(Fate)</em></td>
<td>Studies reporting what happens to the contaminant, rather than what happens to the organism. Studies describing the intermediary metabolism of the contaminant (e.g., radioactive tracer studies) without description of adverse effects.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>FOREIGN LANGUAGE</strong> <em>(FL)</em></td>
<td>Studies in languages other than English.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>FOOD STUDIES</strong> <em>(Food)</em></td>
<td>Food science studies conducted to improve production of food for human consumption.</td>
<td>Wildlife</td>
</tr>
<tr>
<td><strong>FUNGUS</strong> <em>(Fungus)</em></td>
<td>Studies on fungus.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>GENE</strong> <em>(Gene)</em></td>
<td>Studies of genotoxicity (chromosomal aberrations and mutagenicity).</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>HUMAN HEALTH</strong> <em>(HHE)</em></td>
<td>Studies with human subjects.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>IMMUNOLOGY</strong> <em>(IMM)</em></td>
<td>Studies on the effects of contaminants on immunological endpoints.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>INVERTEBRATE</strong> <em>(Invert)</em></td>
<td>Studies that investigate the effects of contaminants on terrestrial invertebrates are excluded.</td>
<td>Wildlife</td>
</tr>
<tr>
<td><strong>IN VITRO</strong> <em>(In Vit)</em></td>
<td><em>In vitro</em> studies, including exposure of cell cultures, excised tissues and/or excised organs.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>LEAD SHOT</strong> <em>(Lead shot)</em></td>
<td>Studies administering lead shot as the exposure form. These studies are labeled separately for possible later retrieval and review.</td>
<td>Wildlife</td>
</tr>
<tr>
<td><strong>MEDIA</strong> <em>(Media)</em></td>
<td>Authors must report that the study was conducted using natural or artificial soil. Studies conducted in pore water or any other aqueous phase (e.g., hydroponic solution), filter paper, petri dishes, manure, organic or histosoils (e.g., peat muck, humus), are not considered suitable for use in defining soil screening levels.</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>METHODS</strong> <em>(Meth)</em></td>
<td>Studies reporting methods or methods development without usable toxicity test results for specific endpoints.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>MINERAL REQUIREMENTS</strong> <em>(Mineral)</em></td>
<td>Studies examining the minerals required for better production of animals for human consumption, unless there is potential for adverse effects.</td>
<td>Wildlife</td>
</tr>
<tr>
<td><strong>MIXTURE</strong> <em>(Mix)</em></td>
<td>Studies that report data for combinations of single toxicants (e.g. cadmium and copper) are excluded. Exposure in a field setting from contaminated natural soils or waste application to soil may be coded as Field Survey.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>Rejection Criteria</td>
<td>Description</td>
<td>Receptor</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td><strong>MODELING</strong> (Model)</td>
<td>Studies reporting the use of existing data for modeling, i.e., no new organism toxicity data are reported. Studies which extrapolate effects based on known relationships between parameters and adverse effects.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO CONTAMINANT OF CONCERN</strong> (No COC)</td>
<td>Studies that do not examine the toxicity of Eco-SSL contaminants of concern.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO CONTROL</strong> (No Control)</td>
<td>Studies which lack a control or which have a control that is classified as invalid for derivation of TRVs.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO DATA</strong> (No Data)</td>
<td>Studies for which results are stated in text but no data is provided. Also refers to studies with insufficient data where results are reported for only one organism per exposure concentration or dose (wildlife).</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO DOSE or CONC</strong> (No Dose)</td>
<td>Studies with no usable dose or concentration reported, or an insufficient number of doses/concentrations are used based on Eco-SSL SOPs. These are usually identified after examination of full paper. This includes studies which examine effects after exposure to contaminant ceases. This also includes studies where offspring are exposed in utero and/or lactation by doses to parents and then after weaning to similar concentrations as their parents. Dose cannot be determined.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO DURATION</strong> (No Dur)</td>
<td>Studies with no exposure duration. These are usually identified after examination of full paper.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO EFFECT</strong> (No Efct)</td>
<td>Studies with no relevant effect evaluated in a biological test species or data not reported for effect discussed.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO ORAL</strong> (No Oral)</td>
<td>Studies using non-oral routes of contaminant administration including intraperitoneal injection, other injection, inhalation, and dermal exposures.</td>
<td>Wildlife</td>
</tr>
<tr>
<td><strong>NO ORGANISM</strong> (No Org) or NO SPECIES</td>
<td>Studies that do not examine or test a viable organism (also see in vitro rejection category).</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NOT AVAILABLE</strong> (Not Avail)</td>
<td>Papers that could not be located. Citation from electronic searches may be incorrect or the source is not readily available.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NOT PRIMARY</strong> (Not Prim)</td>
<td>Papers that are not the original compilation and/or publication of the experimental data.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO TOXICANT</strong> (No Tox)</td>
<td>No toxicant used. Publications often report responses to changes in water or soil chemistry variables, e.g., pH or temperature. Such publications are not included.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO TOX DATA</strong> (No Tox Data)</td>
<td>Studies where toxicant used but no results reported that had a negative impact (plants and soil invertebrates).</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NUTRIENT</strong> (Nutrient)</td>
<td>Nutrition studies reporting no concentration related negative impact.</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NUTRIENT DEFICIENCY</strong> (Nut def)</td>
<td>Studies of the effects of nutrient deficiencies. Nutritional deficient diet is identified by the author. If reviewer is uncertain then the administrator should be consulted. Effects associated with added nutrients are coded.</td>
<td>Wildlife</td>
</tr>
<tr>
<td><strong>NUTRITION</strong> (Nut)</td>
<td>Studies examining the best or minimum level of a chemical in the diet for improvement of health or maintenance of animals in captivity.</td>
<td>Wildlife</td>
</tr>
<tr>
<td><strong>OTHER AMBIENT CONDITIONS</strong> (OAC)</td>
<td>Studies which examine other ambient conditions: pH, salinity, DO, UV, radiation, etc.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>Rejection Criteria</td>
<td>Description</td>
<td>Receptor</td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>OIL (Oil)</td>
<td>Studies which examine the effects of oil and petroleum products.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>OM, pH (OM, pH)</td>
<td>Organic matter content of the test soil must be reported by the authors, but may be presented in one of the following ways; total organic carbon (TOC), particulate organic carbon (POC), organic carbon (OC), coarse particulate organic matter (CPOM), particulate organic matter (POM), ash free dry weight of soil, ash free dry mass of soil, percent organic matter, percent peat, loss on ignition (LOI), organic matter content (OMC). With the exception of studies on non-ionizing substances, the study must report the pH of the soil, and the soil pH should be within the range of 4 and 8.5. Studies that do not report pH or report pH outside this range are rejected.</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ORGANIC METAL (Org Met)</td>
<td>Studies which examine the effects of organic metals. This includes tetraethyl lead, triethyl lead, chromium picolinate, phenylarsonic acid, roxarsone, 3-nitro-4-phenylarsonic acid, zinc phosphide, monomethylarsonic acid (MMA), dimethylarsinic acid (DMA), trimethylarsine oxide (TMAO), or arsenobetaine (AsBe) and other organo metallic fungicides. Metal acetates and methionines are not rejected and are evaluated.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>LEAD BEHAVIOR OR HIGH DOSE MODELS (Pb Behav)</td>
<td>There are a high number of studies in the literature that expose rats or mice to high concentrations of lead in drinking water (0.1, 1 to 2% solutions) and then observe behavior in offspring, and/or pathology changes in the brain of the exposed dam and/or the progeny. Only a representative subset of these studies were coded. Behavior studies examining complex behavior (learned tasks) were also not coded.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>PHYSIOLOGY STUDIES (Phys)</td>
<td>Physiology studies where adverse effects are not associated with exposure to contaminants of concern.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>PLANT (Plant)</td>
<td>Studies of terrestrial plants are excluded.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>PRIMATE (Prim)</td>
<td>Primate studies are excluded.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>PUBL AS (Publ as)</td>
<td>The author states that the information in this report has been published in another source. Data are recorded from only one source. The secondary citation is noted as Publ As.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>QSAR (QSAR)</td>
<td>Derivation of Quantitative Structure-Activity Relationships (QSAR) is a form of modeling. QSAR publications are rejected if raw toxicity data are not reported or if the toxicity data are published elsewhere as original data.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>REGULATIONS (Reg)</td>
<td>Regulations and related publications that are not a primary source of data.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>REVIEW (Rev)</td>
<td>Studies in which the data reported in the article are not primary data from research conducted by the author. The publication is a compilation of data published elsewhere. These publications are reviewed manually to identify other relevant literature.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>Rejection Criteria</td>
<td>Description</td>
<td>Receptor</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>SEDIMENT CONC (Sed)</td>
<td>Studies in which the only exposure concentration/dose reported is for the level of a toxicant in sediment.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>SCORE (Score)</td>
<td>Papers in which all studies had data evaluation scores at or lower than the acceptable cut-off (≤10 of 18) for plants and soil invertebrates.</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>SEDIMENT CONC (Sed)</td>
<td>Studies in which the only exposure concentration/dose reported is for the level of a toxicant in sediment.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>SLUDGE</td>
<td>Studies on the effects of ingestion of soils amended with sewage sludge.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>SOIL CONC (Soil)</td>
<td>Studies in which the only exposure concentration/dose reported is for the level of a toxicant in soil.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>SPECIES</td>
<td>Studies in which the species of concern was not a terrestrial invertebrate or plant or mammal or bird.</td>
<td>Plants and Soil Invertebrates Wildlife</td>
</tr>
<tr>
<td>STRESSOR (QAC)</td>
<td>Studies examining the interaction of a stressor (e.g., radiation, heat, etc.) and the contaminant, where the effect of the contaminant alone cannot be isolated.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>SURVEY (Surv)</td>
<td>Studies reporting the toxicity of a contaminant in the field over a period of time. Often neither a duration nor an exposure concentration is reported.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>REPTILE OR AMPHIBIAN (Herp)</td>
<td>Studies on reptiles and amphibians. These papers flagged for possible later review.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>UNRELATED (Unrel)</td>
<td>Studies that are unrelated to contaminant exposure and response and/or the receptor groups of interest.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>WATER QUALITY STUDY (Wqual)</td>
<td>Studies of water quality.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>YEAST (Yeast)</td>
<td>Studies of yeast.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
</tbody>
</table>
Appendix 5-1

Avian Toxicity Data Extracted and Reviewed for Wildlife Toxicity Reference Value (TRV) - Manganese

April 2007
This page intentionally left blank
Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Manganese
Page 1 of 2

Eco-SSL for Manganese

d
d
w
d
d
w

1
14
1
7
7
0

d
d
d
d
d
d

JV
JV
JV
JV
JV
JV

M
M
M
M
M
M

C
C
C
C
C
C

Lab
Lab
Lab
Lab
Lab
Lab

3
3
5
3
3
1

BIO
BIO
BIO
BIO
BIO
BIO

CHM
CHM
HRM
CHM
CHM
CHM

HMGL
HMGL
TSTR
HMGL
HMGL
GLUC

BL
BL
SR
BL
BL
SR

744
4000
575

1488
5000

Manganese oxide
Manganese sulfate monohydrate
Manganese oxide
Manganese oxide

100
100
100
100

Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Japanese quail (Coturnix japonica )

1
1
1
1

4
4
4
2

0/372/744/1488
0/1000/2000/3000
0/1000/2000/3000
0/575

mg/kg diet
N na ADL
mg/kg diet NR na ADL
mg/kg diet NR na ADL
mg/kg bw/d NR na ADL

U
U
U
U

FD 42
FD 3
FD 21
FD 75

d
w
d
d

1
1
1
1

d
d
d
d

JV
JV
JV
JV

M
M
M
M

C
C
C
C

Lab
Lab
Lab
Lab

2
3
2
2

BEH
BEH
BEH
BEH

FDB
FDB
FDB
FDB

FCNS
FCNS
FCNS
FCNS

WO 744
WO 2000
WO 3000
WO 575

Manganese oxide
Manganese sulfate

100 Chicken (Gallus domesticus )
100 Chicken (Gallus domesticus )

1
1

4 0/1000/2000/3000
2 0/1500

mg/kg diet NR na ADL
mg/kg diet N na ADL

U FD 21
U FD 14

d
d

1
4

d
d

JV
JV

M
M

C
C

Lab
Lab

3 PHY
2 PHY

PHY
PHY

FDCV WO 3000
FDCV WO

Manganese sulfate hydrate
Manganese oxide

100 Chicken (Gallus domesticus )
100 Japanese quail (Coturnix japonica )

1
1

3 0/2.6/26
2 0/575

mg/org/d
NR na 2 per d U GV 14
mg/kg bw/d NR na ADL U FD 70

d
d

8
1

d
d

JV
JV

M
M

C
C

Lab
Lab

2
3

PTH ORW ORWT TB
PTH ORW ORWT LI

Manganese oxide
Manganese oxide
Manganese oxide

100 Chicken (Gallus domesticus )
100 Chicken (Gallus domesticus )
100 Japanese quail (Coturnix japonica )

2
2
1

2 0/306
2 0/323
2 0/575

mg/d
NR na ADL
mg/d
NR na ADL
mg/kg bw/d NR na ADL

U FD 12
U FD 12
U FD 75

w
w
d

23
23
1

w
w
d

LB
LB
JV

F
F
M

C
C
C

Lab
Lab
Lab

1
1
4

REP
REP
REP

REP
REP
REP

PROG WO
PROG WO
TEWT TE

Manganese Sulfate
Manganese sulfate
Manganese sulfate monohydrate
Manganese sulfate hydrate
Manganese sulfate hydrate
Manganese sulfate monohydrate
Manganese
Manganese sulfate
Manganese sulfate monohydrate
Manganese oxide
Manganese sulfate hydrate
Manganese oxide
Manganese oxide
Manganese sulfate hydroxide
Manganese chloride tetrahydrate
Manganese sulfate monohydrate
Manganese dioxide
Manganese sulfate hydrate
Manganese carbonate
Manganese oxide
Manganous oxide

100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100

Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Turkey (Meleagris gallopavo )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Japanese quail (Coturnix japonica )
Chicken (Gallus domesticus )

1
1
1
1
1
1
1
1
1
1
2
2
1
1
4
1
4
4
4
1
1

5
3
3
3
2
2
2
2
4
4
4
4
4
3
4
9
4
4
4
2
5

mg/org/d
mg/kg diet
mg/org
mg/org/d
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg bw/d
mg/kg diet

U
U
U
U
U
U
U
U
U
U
U
U
U
U
U
U
U
U
U
U
U

7
4
14
14
21
14
1
14
3
21
21
21
14
14
14
21
14
14
14
75
21

w
w
d
d
d
d
w
d
w
d
d
d
d
d
d
d
d
d
d
d
d

1
w JV
1
d JV
8
d JV
8
d JV
1
d JV
8
d JV
2
w JV
4
d JV
1
d JV
1
d JV
1
d JV
1
d JV
1
d JV
8
d JV
7
d JV
NR NR JV
7
d JV
7
d JV
7
d JV
1
d JV
1
d JV

M
B
M
M
M
M
B
M
M
M
M
M
M
M
M
B
M
M
M
M
M

C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C

Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab

1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1

GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO

GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO
GRO

BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT
BDWT

Manganese
Manganese sulfate monohydrate

100 Chicken (Gallus domesticus )
100 Turkey (Meleagris gallopavo )

1
1

4 0/1000/2000/4000
mg/kg diet
9 0/510/1020/2040/3000/3060/3620/4080/4800 mg/kg diet

NR na ADL
NR na ADL

U FD 26
U FD 21

d
d

4
d JV
NR NR JV

B
B

C
C

Lab
Lab

Manganese Sulfate
Manganese Sulfate
Manganese oxide
Manganese oxide
Manganese sulfate hydrate
Manganese sulfate hydrate
Manganese sulfate hydrate
Manganese sulfate monohydrate

100
100
100
100
100
100
100
100

1
1
1
1
1
1
1
1

5
5
4
4
2
2
2
2

NR
NR
N
N
NR
NR
NR
NR

U
U
U
U
U
U
U
U

w
w
d
d
d
d
d
d

M
M
M
M
M
M
M
M

C
C
C
C
C
C
C
C

Lab
Lab
Lab
Lab
Lab
Lab
Lab
Lab

Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )

0/5.85/6.61/7.44/11.64
0/5.85/6.61/7.44/11.64
0/372/744/1488
0/372/744/1488
0/1000
0/1000
0/1000
0/1000

mg/org/d
mg/org/d
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet
mg/kg diet

NR
NR
NR
NR
NR
NR
NR
N
NR
NR
NR
NR
N
NR
NR
NR
NR
NR
NR
NR
NR

na
na
na
na
na
na
na
na
na
na
na
na
na
na
na
na
na
na
na
na
na

na
na
na
na
na
na
na
na

ADL
ADL
ADL
2 per d
ADL
ADL
ADL
ADL
ADL
ADL
ADL
ADL
ADL
ADL
ADL
ADL
ADL
ADL
ADL
ADL
ADL

ADL
ADL
ADL
ADL
ADL
ADL
ADL
ADL

FD
FD
FD
GV
FD
FD
FD
FD
FD
FD
FD
FD
FD
FD
FD
FD
FD
FD
FD
FD
FD

FD
FD
FD
FD
FD
FD
FD
FD

7
7
42
42
21
21
21
14

1
1
1
1
1
1
1
8

w
w
d
d
d
d
d
d

JV
JV
JV
JV
JV
JV
JV
JV

WO
WO
WO
WO
WO
WO
WO
WO
WO
WO
WO
WO
WO
WO
WO
WO
WO
WO
WO
WO
WO

WO
WO
HE
WO
WO
WO
IN
BL

3000
3000
5000

11.64
11.64
1488
1488
1000
1000
1000
1000

1488
3000

1500

1488
4000
4800

Total

14
14
10
14
14
10

Test Conditions

FD
FD
FD
FD
FD
FD

10
10
10
10
10
10

10
10
10
10
10
10

5
5
5
5
5
5

10 7
10 6
10 10
10 6
10 6
10 5

1
1
1
1
1
1

10
10
4
4
4
4

10
10
3
10
10
10

10
10
10
10
10
10

4
4
4
4
4
4

77
76
67
70
70
69

10
10
10
10

10
10
10
10

5
5
5
5

10 7
10 7
10 7
10 10

4
4
4
4

10 10 10
10 10 10
4 10 10
4 1 10

4
4
4
4

80
80
74
68

10 10
10 10

5
5

10
10

6
6

4
4

4
4

10 10
10 10

4
4

73
73

67.0
575

10 8 10 10 6
10 10 5 10 10

4
4

4
4

1 10
10 10

4
4

67
77

0.99
0.98
1.9697

191
202
575

10 10
10 10
10 10

10 6 10
10 6 10
10 10 10

4
4
4

1
1
8

10
10
10

4
4
4

70
70
81

Y
N
N
N
Y
N
N
N
Y
Y
N
N
Y
N
N
N
N
N
N
Y
Y

0.05401
0.0375
0.04009
0.03142
0.0405
0.02709
0.0222
0.03773
0.0306
0.0362
0.04009
0.04009
0.07886
0.02938
0.02749
0.03706
0.02749
0.02721
0.02704
1.9697
0.7178

23.1
24.3
50.2
67.0
71.8
87.7
97.6
110
197
202
213
213
215
252
261
302
435
437
439
575
1120

10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10

8
8
8
8
8
8
8
8
8
8
8
8
8
8
8
8
8
8
8
8
8

4
4
4
4
4
4
4
4
4
4
4
4
10
4
10
10
4
4
4
4
4

1
1
1
1
1
1
10
10
1
6
1
1
10
1
10
10
1
1
1
10
1

10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10
10

4
4
4
4
4
4
4
4
4
4
4
4
4
4
4
4
4
4
4
4
4

69
68
67
71
68
68
71
77
69
74
67
67
84
68
83
82
68
68
68
81
68

1.042
0.5

Y
N

0.0563
0.03706

216
356

10 10
10 10

5
5

4
10

6
5

9
9

4
4

10 10
1 10

4
4

72
68

0.5033
0.5033
1.7524
1.7524
0.564
0.564
0.564
0.309

Y
Y
Y
Y
Y
Y
Y
N

5.4E-05
5.4E-05
0.07886
0.07886
0.0405
0.0405
0.0405
0.02709

23.1
23.1
67.0
67.0
71.8
71.8
71.8
87.7

10
10
10
10
10
10
10
10

5
5
5
5
5
5
5
5

10
10
10
10
10
10
10
10

7
7
7
7
6
6
6
6

4
4
4
4
4
4
4
1

4
4
4
4
4
4
4
4

1
1
1
1
1
1
1
1

4
4
4
4
4
4
4
4

65
65
65
65
64
64
64
61

261
264
674
58.6
192

110

431
348
356

5
5
5

Chemical form

U
U
U
U
U
U

Conc/ Doses

ADL
ADL
ADL
ADL
ADL
ADL

Test Species

na
na
na
na
na
na

Exposure Duration

Y
Y
Y
Y
N
N
N
Y

N
NR
NR
NR
NR
NR

Statistical Power

3 BEH FDB FCNS
2 PHY PHY FDCV
4 PTH ORW ORWT
5 PHY PHY FDCV
2 BEH FDB FCNS
4 PHY PHY FDCV
3 PTH ORW SMIX
3 BIO CHM HMGL

mg/kg diet
mg/kg diet
mg/kg bw/d
mg/kg diet
mg/kg diet
mg/kg diet

Dose Range

N
N

0/372/744/1488
0/3000/4000/5000
0/575
0/3000/4000/5000
0/3000/4000/5000
0/5000

Endpoint

2 MOR MOR MORT WO 4000
2 MOR MOR MORT WO 4800

4
4
2
4
4
2

Dose Quantification

LOAEL Dose (mg/kg/day)

0.5033
0.509
0.564
0.388
0.564
0.309
0.2276
0.5139
0.4668
0.5376
0.564
0.564
0.2723
0.35
0.316
0.5
0.316
0.311
0.308
0.099
0.564

1
4
1
4
4
1

Test Concentrations

NOAEL Dose (mg/kg/day)

Y
Y
N
Y
N
Y
Y
Y
Y
Y
N
N
Y
Y
Y
N
Y
Y
Y
Y
N

Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Japanese quail (Coturnix japonica )
Chicken (Gallus domesticus )
Chicken (Gallus domesticus )
Japanese quail (Coturnix japonica )

Dose Route

Ingestion Rate in kg/day or
L/day

11.64
330
28.29
26
1000
1000
1000
1500
3000
3000
3000
3000
744
3000
3000
4080
5000
5000
5000
575
880

100
100
100
100
100
100

Data Evaluation Score

Data Source

Ingestion Rate Reported?
Y
Y
Y

Study LOAEL

1.6
1.6
0.099

Study NOAEL

N
N
Y

Response Site

306
323
575

Effect Measure

0.03142
1.9697

Effect Type

N
Y

General Effect Group

0.388
0.099

Endpoint Number

Y
Y

Test Location

26
575

Control Type

217

Sex

0.03886
0.03773

Lifestage

N
N

Age Units

0.5376
0.5139

Age

Y
Y

Duration Units

29.3
128
202
575

Exposure Duration

0.07278
0.0329
0.0362
1.9697

Route of Exposure

Y
Y
Y
Y

Method of Analyses

1.8493
0.5151
0.5376
0.099

Application Frequency

Y
Y
Y
Y

Percent Moisture

398
434

Wet Weight Reported?

199
347
575

Conc/Dose Units

0.07278
0.02761
1.9697
0.02749
0.02687
0.01214

# of Conc/ Doses

Y
N
Y
N
N
N

Phase #

0.2723
0.318
0.099
0.316
0.305
0.09

MW%

Y
Y
Y
Y
Y
N

Manganese oxide
Manganese sulfate hydrate
Manganese oxide
Manganese chloride tetrahydrate
Manganese carbonate
Manganes oxide (Mn3O4)

0/5.85/6.61/7.44/11.64
0/220/330
0/13.6/28.29
0/2.6/26
0/1000
0/1000
0/1000
0/1500
0/1000/2000/3000
0/1000/2000/3000
0/1000/2000/3000
0/1000/2000/3000
0/372/744/1488
0/1500/3000
0/3000/4000/5000
0/510/1020/2040/3000/3060/3620/4080/4800
0/3000/4000/5000
0/3000/4000/5000
0/3000/4000/5000
0/575
0/110/220/440/880

Result

Body Weight in kg

Conversion to mg/kg bw/day

Chemical Form

Biochemical
1
5345 Martinez and Diaz, 1996
2
6363 Southern and Baker, 1983
3
8426 Laskey and Edens, 1985
4
6363 Southern and Baker, 1983
5
6363 Southern and Baker, 1983
6
7710 Edens and Laskey, 1990
Behavior
7
5345 Martinez and Diaz, 1996
8
6195 Black et al., 1985
9
6305 Black et al, 1984
10
8426 Laskey and Edens, 1985
Physiology
11
6305 Black et al, 1984
12
6215 Brown and Southern, 1985
Pathology
13
6054 Halpin et al, 1986
14
8426 Laskey and Edens, 1985
Reproduction
15
5474 Sazzad et al, 1994
16
5474 Sazzad et al, 1994
17
8426 Laskey and Edens, 1985
Growth
18
6772 Spulkamy et al, 1976
19
7191 Settle et al, 1969
20
5728 Wedekind and Baker, 1990
21
6054 Halpin et al, 1986
22
6087 Henry et al., 1986
23
5700 Baker and Halpin, 1991
24 44196 De Rosa et al, 1980
25
6215 Brown and Southern, 1985
26
6195 Black et al., 1985
27
6305 Black et al, 1984
28
5788 Wong-Valle et al, 1989
29
5788 Wong-Valle et al, 1989
30
5345 Martinez and Diaz, 1996
31
6382 Southern and Baker, 1983
32
6363 Southern and Baker, 1983
33 14404 Vohra and Kratzer, 1968
34
6363 Southern and Baker, 1983
35
6363 Southern and Baker, 1983
36
6363 Southern and Baker, 1983
37
8426 Laskey and Edens, 1985
38
2196 Leeson and Summers, 1982
Survival
39
6252 Black et al., 1984
40 14404 Vohra and Kratzer, 1968
Data Not Used to Derive TRV
41
6772 Spulkamy et al, 1976
42
6772 Spulkamy et al, 1976
43
5345 Martinez and Diaz, 1996
44
5345 Martinez and Diaz, 1996
45
6087 Henry et al., 1986
46
6087 Henry et al., 1986
47
6087 Henry et al., 1986
48
5700 Baker and Halpin, 1991

Effects

Body Weight Reported?

Exposure

Reference

Ref N.

Result #

Ref

10 5 10 7
10 5 10 6
10 5 10 5
8 10 10 6
10 5 10 6
10 5 10 6
10 5 4 6
10 5 10 6
10 5 10 7
10 5 10 7
10 5 10 5
10 5 10 5
10 5 10 7
10 5 10 6
10 5 10 6
10 5 10 5
10 5 10 6
10 5 10 6
10 5 10 6
10 5 10 10
10 5 10 6

10
10
10
10
10
10
10
10

April 2007

10
10
10
10
10
10
10
10


<table>
<thead>
<tr>
<th>Ref</th>
<th>Chemical Form</th>
<th>Test Species</th>
<th>Phase #</th>
<th># of Conc/Doses</th>
<th>Conc/Doses Units</th>
<th>Wet Weight Reported?</th>
<th>Percent Moisture</th>
<th>Application Frequency</th>
<th>Age</th>
<th>Age Units</th>
<th>General Effect Group</th>
<th>Effect Measure</th>
<th>Response Site</th>
<th>Body Weight Reported?</th>
<th>Body Weight in kg</th>
<th>Total Ingestion Rate Reported?</th>
<th>L/day</th>
<th>Statistical Power</th>
<th>Dose Quantification</th>
<th>Lore</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>49</td>
<td>Manganese oxide</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>1 2 0/1000 mg/kg diet</td>
<td>NR na</td>
<td>ADL U FD 14 d 8 d JV M C Lab 2 PHY PHY FDCV WO</td>
<td>1000 Y 0.309 N 0.02709 47.7</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Manganese chloride tetrahydrate</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>3 3 0/323 mg/d</td>
<td>NR na</td>
<td>ADL U FD 12 w 23 w SM F C Lab 3 BEH FDB FCNS WO</td>
<td>323 N 1.6 Y 0.99 191</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Manganese sulfate monohydrate</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>1 3 0/13.6/28.29 mg/org</td>
<td>NR na</td>
<td>ADL U FD 14 d 8 d JV M C Lab 3 PHY PHY FDCV WO</td>
<td>28.29 N 0.564 N 0.04009 50.2</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Manganese chloride tetrahydrate</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>2 4 0/1000/2000/3000 mg/kg diet</td>
<td>NR na</td>
<td>ADL U FD 21 d 1 d JV M C Lab 2 BEH FDB FCNS WO</td>
<td>3000 N 0.564 Y 0.0349 186</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>Manganese chloride tetrahydrate</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>1 4 0/1000/2000/3000 mg/kg diet</td>
<td>NR na</td>
<td>ADL U FD 21 d 1 d JV M C Lab 2 BEH FDB FCNS WO</td>
<td>3000 N 0.564 Y 0.0349 186</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Manganese oxide</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>4 4 0/3000/4000/5000 mg/kg diet</td>
<td>NR na</td>
<td>ADL U FD 14 d 7 d JV M C Lab 3 PHY PHY FDCV WO</td>
<td>5000 Y 0.316 N 0.02749 437</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>Manganese oxide</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>4 4 0/3000/4000/5000 mg/kg diet</td>
<td>NR na</td>
<td>ADL U FD 14 d 7 d JV M C Lab 2 PHY PHY FDCV WO</td>
<td>5000 Y 0.311 N 0.02721 437</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>Manganese oxide</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>2 2 0/323 mg/d</td>
<td>NR na</td>
<td>ADL U FD 12 w 23 w SM F C Lab 3 BEH FDB FCNS WO</td>
<td>323 N 1.6 Y 0.98 202</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>Manganese oxide</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>2 4 0/1000/2000/3000 mg/kg diet</td>
<td>NR na</td>
<td>ADL U FD 21 d 1 d JV M C Lab 3 PHY PHY FDCV WO</td>
<td>3000 N 0.564 N 0.04009 213</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>Manganese chloride tetrahydrate</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>1 3 0/1500/3000 mg/kg diet</td>
<td>NR na</td>
<td>ADL U FD 14 d 8 d JV M C Lab 3 BIO CHM HMGL BL</td>
<td>3000 Y 0.35 N 0.02938 252</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>Manganese chloride tetrahydrate</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>4 4 0/3000/4000/5000 mg/kg diet</td>
<td>NR na</td>
<td>ADL U FD 14 d 7 d JV M C Lab 3 BIO CHM HMGL BL</td>
<td>5000 Y 0.316 N 0.02749 437</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>Manganese chloride tetrahydrate</td>
<td>100 Chicken (Gallus domesticus )</td>
<td>4 4 0/3000/4000/5000 mg/kg diet</td>
<td>NR na</td>
<td>ADL U FD 14 d 7 d JV M C Lab 2 PHY PHY FDCV WO</td>
<td>5000 Y 0.316 N 0.02749 437</td>
<td>10 10 5 4 3 4 4 4 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*NOAEL and LOAEL values that are equal and from the same reference represent different experimental designs. These are designated with different Phase numbers.
Appendix 6-1

Mammalian Toxicity Data Extracted and Reviewed for Wildlife Toxicity Reference Value (TRV) - Manganese

April 2007
This page intentionally left blank
### Appendix 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

#### Manganese

<table>
<thead>
<tr>
<th>Ref</th>
<th>Chem. Form</th>
<th>Species</th>
<th>Route</th>
<th>Dose</th>
<th>Duration</th>
<th>Age</th>
<th>Age Units</th>
<th>Chemicals Admin.</th>
<th>Route of Exposure</th>
<th>Exposed Part</th>
<th>Chemical Exposure</th>
<th>Effect Measure</th>
<th>Response Site</th>
<th>Study LOAEL</th>
<th>Body Weight in kg</th>
<th>Total</th>
<th>Statistical Power</th>
<th>Dose Range</th>
<th>Endpoint</th>
<th>Conv. to mg/kg bw/day</th>
<th>Conversion to mg/kg bw/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manganese chloride</td>
<td>Rat (Rattus norvegicus)</td>
<td>0/0.36% in diet</td>
<td>NR</td>
<td>na</td>
<td>ADL</td>
<td>U</td>
<td>DR</td>
<td>5 mo</td>
<td>NR</td>
<td>NR</td>
<td>JV</td>
<td>M</td>
<td>C</td>
<td>Lab 2</td>
<td>BIO</td>
<td>CHM</td>
<td>HMGL</td>
<td>BL</td>
<td>100</td>
<td>2000</td>
</tr>
<tr>
<td>2</td>
<td>Manganese chloride</td>
<td>Rat (Rattus norvegicus)</td>
<td>0/100/200 mg/kg</td>
<td>NR</td>
<td>na</td>
<td>ADL</td>
<td>U</td>
<td>DR</td>
<td>7 d</td>
<td>20 mo</td>
<td>AD</td>
<td>M</td>
<td>C</td>
<td>Lab 1</td>
<td>BIO</td>
<td>HRM</td>
<td>DOPA</td>
<td>BR</td>
<td>100</td>
<td>200</td>
<td>Y</td>
</tr>
<tr>
<td>3</td>
<td>Manganese chloride</td>
<td>Rat (Rattus norvegicus)</td>
<td>0/0.1/5 mg/ml</td>
<td>NR</td>
<td>na</td>
<td>ADL</td>
<td>U</td>
<td>DR</td>
<td>1 mo</td>
<td>NR</td>
<td>NR</td>
<td>JV</td>
<td>M</td>
<td>C</td>
<td>Lab 2</td>
<td>BIO</td>
<td>ENZ</td>
<td>GENZ</td>
<td>BR</td>
<td>10</td>
<td>210</td>
</tr>
<tr>
<td>4</td>
<td>Manganese chloride tetrahydrate</td>
<td>Rat (Rattus norvegicus)</td>
<td>0/1 mg/ml</td>
<td>NR</td>
<td>na</td>
<td>ADL</td>
<td>U</td>
<td>DR</td>
<td>5 w</td>
<td>65 w</td>
<td>JV</td>
<td>M</td>
<td>C</td>
<td>Lab 1</td>
<td>BIO</td>
<td>FDB</td>
<td>FCNS</td>
<td>WO</td>
<td>100</td>
<td>2000</td>
<td>Y</td>
</tr>
<tr>
<td>5</td>
<td>Manganese chloride</td>
<td>Rat (Rattus norvegicus)</td>
<td>0/820/2460/4920 mg/kg</td>
<td>NR</td>
<td>na</td>
<td>ADL</td>
<td>U</td>
<td>FD</td>
<td>84 d</td>
<td>10 w</td>
<td>JV</td>
<td>M</td>
<td>C</td>
<td>Lab 2</td>
<td>BEH</td>
<td>FDB</td>
<td>FCNS</td>
<td>WO</td>
<td>820</td>
<td>2460</td>
<td>Y</td>
</tr>
<tr>
<td>6</td>
<td>Manganese chloride tetrahydrate</td>
<td>Rat (Rattus norvegicus)</td>
<td>0/10 mg/ml</td>
<td>NR</td>
<td>na</td>
<td>ADL</td>
<td>U</td>
<td>DR</td>
<td>11 w</td>
<td>3 w</td>
<td>JV</td>
<td>M</td>
<td>C</td>
<td>Lab 2</td>
<td>BEH</td>
<td>FDB</td>
<td>FCNS</td>
<td>WO</td>
<td>10</td>
<td>20</td>
<td>Y</td>
</tr>
<tr>
<td>7</td>
<td>Manganese chloride</td>
<td>Rat (Rattus norvegicus)</td>
<td>0/554 mg/kg</td>
<td>NR</td>
<td>na</td>
<td>ADL</td>
<td>U</td>
<td>DR</td>
<td>11 w</td>
<td>3 w</td>
<td>JV</td>
<td>M</td>
<td>C</td>
<td>Lab 2</td>
<td>BEH</td>
<td>FDB</td>
<td>FCNS</td>
<td>WO</td>
<td>554</td>
<td>1000</td>
<td>Y</td>
</tr>
</tbody>
</table>

---

Eco-SSL for Manganese

April 2007
| Ref | Study Date | Study 1 | Study 2 | Concentration Form | Chemical Form | Chemical Name | Species | Dose | Age | Route of Exposure | Age Units | Data Source | Consistency | Data Source | Data Source | Data Source | Data Source | Data Source |
|-----|------------|---------|---------|-------------------|--------------|--------------|---------|------|-----|------------------|-----------|-------------|--------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 52  | 1985       | Black et al, 1985 | Sheep (Ovis aries) | 100 ppm Manganese (III) oxide | Manganese oxide | Sheep | Ovis aries | 4000 | mg/kg | Diet | 2 mo | JV | M | C | Lab 4 | PHY | PHY | FDCV | WO | 1000 | 2000 | Y | 46.2 | Y | 1.46 | 31.6 | 63.2 | 10 | 10 | 5 | 10 | 7 | 4 | 10 | 10 | 10 | 4 | 80 |
| 53  | 1990       | Black and Fechter, 1990 | Rat (Rattus norvegicus) | 300 ppm Manganese (III) oxide | Manganese oxide | Rat | Rattus norvegicus | 1000 | mg/kg | Diet | 1 mo | JV | M | C | Lab 4 | PHY | PHY | FDCV | WO | 2000 | 4000 | Y | 38.4 | Y | 1.14 | 59.4 | 119 | 10 | 10 | 5 | 10 | 7 | 8 | 10 | 10 | 10 | 4 | 84 |
| 54  | 1990       | Derevenco et al, 1988 | Rattus norvegicus | 50 ppm Manganese (II) carbonate | Manganese carbonate | Rat | Rattus norvegicus | 250 | mg/kg | Diet | 1 mo | JV | M | C | Lab 4 | PHY | PHY | FDCV | WO | 0.0998 | Y | 0.05 | 0.01 | 1996 | 10 | 10 | 5 | 10 | 7 | 10 | 10 | 10 | 4 | 80 |

### Summary

Eco-SSL for Manganese

April 2007
<table>
<thead>
<tr>
<th>Ref</th>
<th>Study NOAEL</th>
<th>Study LOAEL</th>
<th>Conc/Dose Units</th>
<th>Wet Weight Reported?</th>
<th>Test Concentrations</th>
<th>Ingestion Rate Report?</th>
<th>Exposure Duration</th>
<th>Ingestion Rate Reported?</th>
<th>Test Conditions</th>
<th>Body Weight in kg</th>
<th>Ingestion Rate in kg or L/day</th>
<th>Exposure Duration</th>
<th>Test Location</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>115</td>
<td>35742</td>
<td>100</td>
<td>Pig (Sus scrofa)</td>
<td>0/50 mg/kg diet</td>
<td>NR</td>
<td>NR</td>
<td>22-28 w</td>
<td>50</td>
<td>PHY PHY FDCV WO 50</td>
<td>Y</td>
<td>229.8</td>
<td>N 6.00</td>
<td>1.30</td>
<td>10 5 5 10 6 1 4 4 1 10 4 64</td>
</tr>
<tr>
<td>116</td>
<td>81</td>
<td>100</td>
<td>Pig (Sus scrofa)</td>
<td>0/100 mg/L</td>
<td>NR</td>
<td>NR</td>
<td>91 d</td>
<td>AD F C Lab 100</td>
<td>BEH FDB WCON NR 100</td>
<td>Y</td>
<td>0.33</td>
<td>N 0.0365</td>
<td>11.1</td>
<td>10 5 5 10 6 4 4 1 10 4 59</td>
</tr>
<tr>
<td>117</td>
<td>135</td>
<td>100</td>
<td>Sheep (Ovis arie)</td>
<td>0/3 mg/ml</td>
<td>NR</td>
<td>NR</td>
<td>90 d</td>
<td>AD M C Lab 3</td>
<td>PTH ITX CONV WO 3</td>
<td>N</td>
<td>0.4702</td>
<td>N 0.050198</td>
<td>320</td>
<td>10 554544 1 0 1 0 4 6 1</td>
</tr>
<tr>
<td>118</td>
<td>55</td>
<td>100</td>
<td>Rat (Rattus norvegicus)</td>
<td>0/1 mg/ml</td>
<td>NR</td>
<td>NR</td>
<td>40 d</td>
<td>AD M C Lab 1</td>
<td>OTH PY 1</td>
<td>N</td>
<td>0.267</td>
<td>N 0.030164</td>
<td>24.3</td>
<td>10 5 5 10 5 10 4 10 10 4 78</td>
</tr>
<tr>
<td>119</td>
<td>34892</td>
<td>100</td>
<td>Hamster</td>
<td>0/4000 mg/kg diet</td>
<td>NR</td>
<td>NR</td>
<td>2 w</td>
<td>PHY PHY FDCV WO 4000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>14468</td>
<td>100</td>
<td>Pig (Sus scrofa)</td>
<td>0/1000 mg/kg diet</td>
<td>NR</td>
<td>NR</td>
<td>2 w</td>
<td>PHY PHY FDCV WO 1000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>121</td>
<td>14468</td>
<td>100</td>
<td>Pig (Sus scrofa)</td>
<td>0/25/75/225/675/2025 mg/kg diet</td>
<td>NR</td>
<td>NR</td>
<td>2 w</td>
<td>PHY PHY FDCV WO 2025</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>122</td>
<td>126</td>
<td>100</td>
<td>Sheep (Ovis arie)</td>
<td>0/3 mg/ml</td>
<td>NR</td>
<td>NR</td>
<td>90 d</td>
<td>ITX CONV WO 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>123</td>
<td>35824</td>
<td>100</td>
<td>Sheep (Ovis arie)</td>
<td>0/2 g/kg  diet</td>
<td>NR</td>
<td>NR</td>
<td>100 d</td>
<td>FCNS WO 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>124</td>
<td>33786</td>
<td>100</td>
<td>Mouse (Mus musculus)</td>
<td>0/400/1100/3550 mg/kg diet</td>
<td>NR</td>
<td>NR</td>
<td>43 d</td>
<td>OTHR PY 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>55</td>
<td>100</td>
<td>Rat (Rattus norvegicus)</td>
<td>0/1 mg/ml</td>
<td>NR</td>
<td>NR</td>
<td>40 d</td>
<td>REP REP OTHR PY 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>126</td>
<td>35501</td>
<td>100</td>
<td>Sheep (Ovis arie)</td>
<td>0/3 mg/ml</td>
<td>NR</td>
<td>NR</td>
<td>3 w</td>
<td>CONV WO 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>127</td>
<td>1717</td>
<td>24.07</td>
<td>Rat (Rattus norvegicus)</td>
<td>0/3 mg/ml</td>
<td>NR</td>
<td>NR</td>
<td>90 d</td>
<td>CONV WO 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>128</td>
<td>35726</td>
<td>100</td>
<td>Rat (Rattus norvegicus)</td>
<td>0/3 mg/ml</td>
<td>NR</td>
<td>NR</td>
<td>90 d</td>
<td>CONV WO 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*All abbreviations and definitions are used in coding studies are available from Attachment 4-3 of the Eco-SSL guidance (U.S. EPA 2003)*.

*NOAEL and LOAEL values that are equal and from the same reference represent different experimental designs. These are designated with different Phase numbers.*