Ecological Soil Screening Levels for Cobalt

Interim Final

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U.S. Environmental Protection Agency
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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 soil or ingest biota that live in or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: plants, soil invertebrates, bird and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. Eco-SSLs for wildlife are derived to be protective of the representative of the conservative end of the distribution in order to make estimates for local populations. The Eco-SSLs are conservative 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 these Eco-SSLs as cleanup standards.

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

This document provides the Eco-SSL values for cobalt and the documentation for their derivation. This document provides guidance and is designed to communicate national policy on identifying cobalt 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.

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). The derivation procedures represent the collaborative effort of a multi-stakeholder group consisting of federal, state, consulting, industry, and academic participants led by the U.S. EPA, Office of Solid Waste and Emergency Response.

This document provides the Eco-SSL values for cobalt and the documentation for their derivation. This document provides guidance and is designed to communicate national policy on identifying cobalt 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.

2.0 SUMMARY OF ECO-SSLs FOR COBALT

Cobalt belongs to Group VIII of the periodic classification of elements and shares properties with nickel and iron. Cobalt is a relatively rare element in the earth's crust (0.0023%) and is usually found in association with other metals such as copper, nickel, manganese, and arsenic. Release of cobalt to the environment occurs via soil and natural dust, seawater spray, volcanic eruptions, forest fires, and other continental and marine biogenic emissions. Anthropogenic sources include fossil fuel burning, processing of cobalt-containing alloys, copper and nickel smelting and refining, sewage sludge, and agricultural use of phosphate fertilizers.

Cobalt is an essential trace metal that functions as a component of vitamin $B_{12.}$ Vitamin B_{12} acts as coenzyme in many enzymatic reactions, including some involved in hematopoiesis, and is essential to growth and normal neural function. Non-ruminant animals require dietary intake of cobalt in the physiologically active form of vitamin B_{12}. Intake of inorganic cobalt is sufficient to meet the nutritional requirements of ruminant animals, since ruminal microorganisms have the capacity to biosynthesize vitamin B_{12} (Henry, 1995). No other essential functions of cobalt have been identified.

Although cobalt is an essential nutrient, excessive oral doses result in a variety of adverse responses. The best characterized toxic responses are increases in red blood cell counts (polycythemia), cardiomyopathy, and effects on the male reproductive system (Paternain et al., 1988; Haga et al., 1996, Pedigo and Vernon, 1993). In addition, reduced food and water intake and growth inhibition are commonly observed (Diaz et al., 1994a; 1994b). At present, the mechanisms underlying cobalt toxicity are poorly understood.

In the terrestrial environment, the availability of cobalt is primarily regulated by pH and is usually found in soils as divalent cobalt. At low pH it is oxidized to trivalent cobalt and often found associated with iron. Adsorption of divalent cobalt on soil colloids is high between pH 6 and 7, whereas leaching and plant uptake of cobalt are enhanced by a lower pH. Soil pH is very important in cobalt uptake by plants and phytotoxicity. More acidic soils sorb cobalt less strongly (http://toxnet.nlm.nih.gov).

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

Table 2.1 Cobalt Eco-SSLs (mg/kg dry weight in soil)

Plants	Soil Invertebrates	Wildlife	
		Avian	Mammalian
13	NA	120	230

NA = Not Available. Data were insufficient to derive an Eco-SSL.

Eco-SSL values for cobalt were derived for plants and avian and mammalian wildlife. Eco-SSL values for cobalt could not be derived for soil invertebrates as data were insufficient. The Eco-SSLs range from 13 mg/kg dry weight (dw) for plants to 230 mg/kg dw for mammalian wildlife. These concentrations are higher than the reported range of background soil concentrations in eastern and western U.S. soils (Figure 2.1). Background concentrations of many metals in U.S. soils are described in Attachment 1-4 of the Eco-SSL guidance (U.S. EPA, 2003).

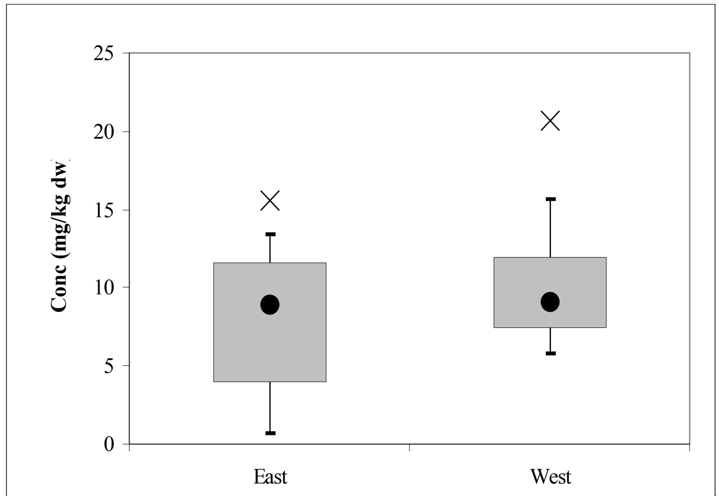
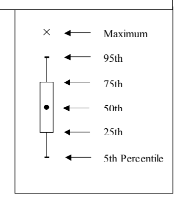


Figure 2.1 Typical Background Concentrations of Cobalt in U.S. Soils



3.0 ECO-SSL FOR TERRESTRIAL PLANTS

Of the papers identified from the literature search process, 152 were selected for acquisition for further review. Of those papers acquired, four 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). Seven studies received an Evaluation Score greater than ten. These studies are summarized in Table 3.1.

The data in Table 3.1 are sorted by bioavailability score and all study results with a bioavailability score of two are used to derive the plant Eco-SSL for cobalt. Six separate studies are used to derive the plant Eco-SSL according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). The Eco-SSL is the geometric mean of the EC_{20} values reported for each of three test species under two separate test conditions (pH and % organic matter (OM)) and is equal to 13 mg/kg dw.

4.0 ECO-SSL FOR SOIL INVERTEBRATES

A soil invertebrate Eco-SSL could not be derived for cobalt. Of the papers identified from the literature search process, 11 were acquired for further review. Of those acquired, none met all 11 Study Acceptance Criteria (U.S. EPA, 2003; Attachment 3-1).

Table 3.1 Plant Toxicity Data - Cobalt

Reference	Study ID	Test Organism		Soil pH	OM %	Bio-availability Score	ERE	Tox Parameter	Tox Value Soil Conc. (mg/kg dw)	Total Eval. Score	Eligible for Eco-SSL Derivation?	Used for Eco-SSL?
TN & Associates, Inc., 2000	a	Alfalfa	*Medicago Sative*	5.0	5.0	2	GRO	EC_{20}	0.60	18	Y	Y
TN & Associates, Inc., 2000	b	Barley	*Hordeum vilgare*	5.0	5.0	2	GRO	EC_{20}	29.8	18	Y	Y
TN & Associates, Inc., 2000	c	Radish	*Raphanus sative*	5.0	5.0	2	GRO	EC_{20}	14.5	18	Y	Y
TN & Associates, Inc., 2000	d	Alfalfa	*Medicago Sative*	6.3	0.1	2	GRO	EC_{20}	13.4	18	Y	Y
TN & Associates, Inc., 2000	e	Barley	*Hordeum vilgare*	6.3	0.1	2	GRO	EC_{20}	36.4	18	Y	Y
TN & Associates, Inc., 2000	f	Radish	*Raphanus sative*	6.3	0.1	2	GRO	EC_{20}	45.2	18	Y	Y
								Geometric Mean	13.4			
Data not Used to Derive Eco-SSL												
Rehab, F.I., 1978		Cotton	*Gossypium spp.*	6.6	2.4	1	GRO	LOAEC	100	12	Y	N

EC_{20} = Effect concentration for 20% of test population
ERE = Ecologically relevant endpoint
GRO = growth
NOAEC = No-observed adverse effect concentration
LOAEC = Lowest-observed adverse effect concentration
MATC = Maximum acceptable toxicant concentration. Geometric mean of NOAEC and LOAEC.
N = No
OM = Organic matter content
Y = yes
Bioavailability Score described in *Guidance for Developing Eco-SSLs* (USEPA, 2003)
Total Evaluation Score described in *Guidance for Developing Eco-SSLs* (USEPA, 2003)

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 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 4-2) identified 530 papers with possible toxicity data for either avian or mammalian species. Of these papers, 498 were rejected for use as described in Section 7.5. Of the remaining papers, 11 contained data for avian test species. These papers were reviewed and 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 5.1. The complete results are included as Appendix 5-1.

Within the 11 reviewed papers, there are 24 results for biochemical (BIO), behavioral (BEH), pathology (PTH), 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 4-5). These data are plotted in Figure 5.1 and correspond directly with the data presented in Table 5.1. The no-observed adverse effect (NOAEL) values for growth and reproduction are used to calculate a geometric mean NOAEL. 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 growth was calculated at 7.61 mg cobalt/kg bw/day. This value is lower than the lowest bounded LOAEL for either growth or mortality results. Therefore, the TRV is equal to the geometric mean NOAEL at 7.61 mg cobalt/kg bw/day.

5.2 Estimation of Dose and Calculation of the Eco-SSL

Three separate Eco-SSL values were calculated for avian wildlife, one each for three surrogate species representing different trophic groups. The avian Eco-SSLs for cobalt were calculated according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5) and are summarized in Table 5.2.

Table 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Cobalt
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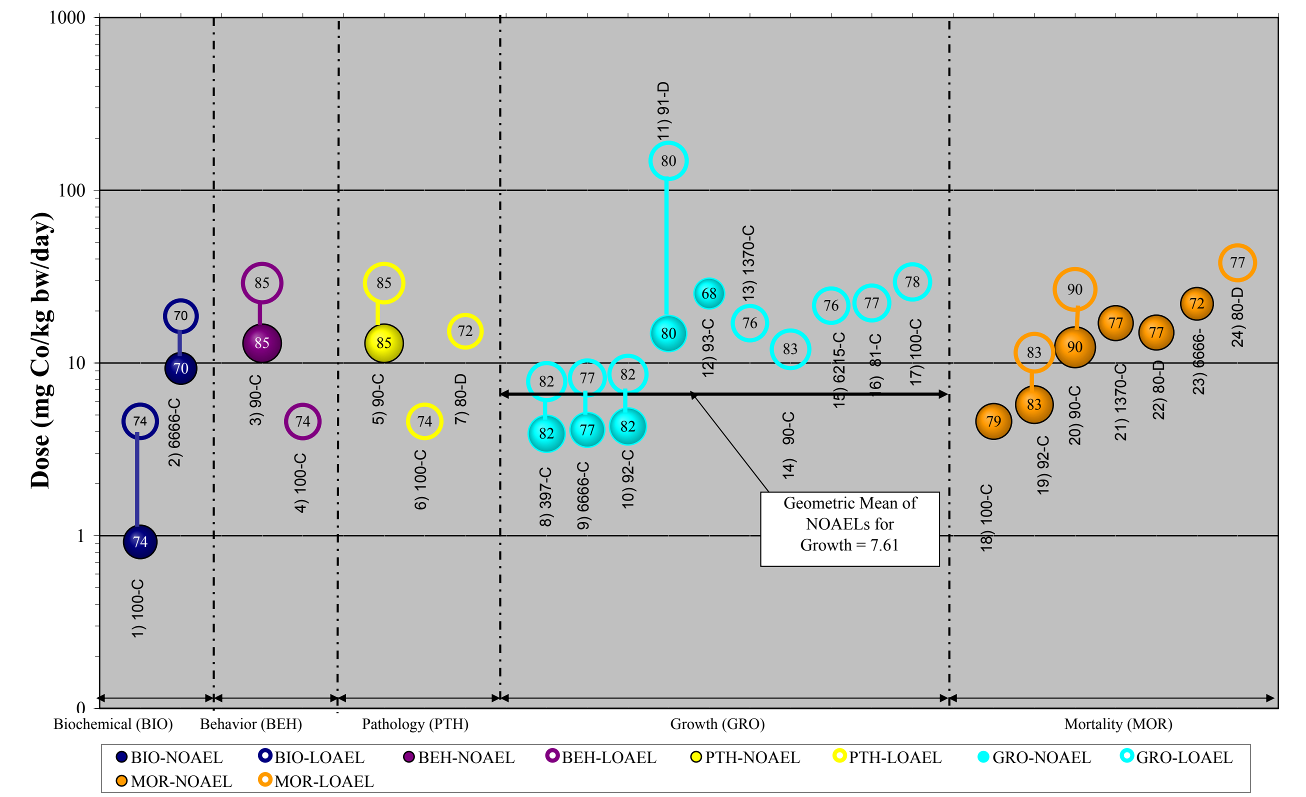
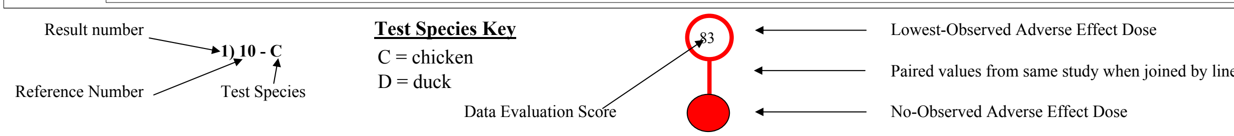
Result #	Reference	Ref No.	Conc/ Doses	Conc/Dose Units	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Effect Group	Effect Measure	Response Site	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Evaluation Score
Biochemical																		
1	Diaz et al., 1994	100	Chicken *(Gallus domesticus)*	4	U	FD	42	d	1	d	JV	B	BIO	RBCE	BL	0.920	4.59	74
2	Ling et al., 1979	6666	Chicken *(Gallus domesticus)*	4	U	FD	3	w	1	d	JV	M	BIO	HMCT	BL	9.30	18.7	70
Behavior																		
3	Diaz et al., 1994	90	Chicken *(Gallus domesticus)*	4	M	FD	14	d	1	d	JV	M	BEH	FCNS	WO	13.0	29.0	85
4	Diaz et al., 1994	100	Chicken *(Gallus domesticus)*	2	U	FD	42	d	1	d	JV	B	BEH	FCNS	WO		4.58	74
Pathology																		
5	Diaz et al., 1994	90	Chicken *(Gallus domesticus)*	4	M	FD	14	d	1	d	JV	M	PTH	GLSN	WO	13.0	29.0	85
6	Diaz et al., 1994	100	Chicken *(Gallus domesticus)*	2	U	FD	42	d	1	d	JV	B	PTH	ORWT	HE		4.59	74
7	Van Vleet et al., 1981	80	Duck (*Anas sp.)*	3	U	FD	15	d	1	d	JV	M	PTH	GLSN	MB		15.3	72
Growth																		
8	Hill, 1979	397	Chicken *(Gallus domesticus)*	4	U	FD	5	w	1	d	JV	F	GRO	BDWT	WO	3.89	7.80	82
9	Ling et al., 1979	6666	Chicken *(Gallus domesticus)*	4	U	FD	3	w	1	d	JV	M	GRO	BDWT	WO	4.10	8.20	77
10	Hill, 1974	92	Chicken *(Gallus domesticus)*	6	U	FD	2	w	1	d	JV	B	GRO	BDWT	WO	4.29	8.59	82
11	Paulov, 1971	91	Duck (*Anas sp.)*	3	U	FD	8	d	2	d	JV	NR	GRO	BDWT	WO	14.8	148	80
12	Berg and Martinson, 1972	93	Chicken *(Gallus domesticus)*	3	U	FD	2	w	1	d	JV	B	GRO	BDWT	WO	25.2		68
13	Hill, 1979	1370	Chicken *(Gallus domesticus)*	2	U	FD	2	w	1	d	JV	B	GRO	BDWT	WO		17.0	76
14	Diaz et al., 1994	90	Chicken *(Gallus domesticus)*	4	M	FD	14	d	1	d	JV	M	GRO	BDWT	WO		12.0	83
15	Brown and Southern, 1985	6215	Chicken *(Gallus domesticus)*	2	U	FD	14	d	0	d	IM	M	GRO	BDWT	WO		21.5	76
16	Southern and Baker, 1981	81	Chicken *(Gallus domesticus)*	3	U	FD	15	d	8	d	JV	M	GRO	BDWT	WO		22.3	77
17	Diaz et al., 1994	100	Chicken *(Gallus domesticus)*	2	U	FD	14	d	1	d	JV	B	GRO	BDWT	WO		29.5	78
Survival																		
18	Diaz et al., 1994	100	Chicken *(Gallus domesticus)*	2	U	FD	42	d	1	d	JV	B	MOR	MORT	WO	4.59		79
19	Hill, 1974	92	Chicken *(Gallus domesticus)*	6	U	FD	5	w	1	d	JV	B	MOR	MORT	NR	5.74	11.5	83
20	Diaz et al., 1994	90	Chicken *(Gallus domesticus)*	4	M	FD	14	d	1	d	JV	M	MOR	MORT	WO	12.3	26.7	90
21	Hill, 1979	1370	Chicken *(Gallus domesticus)*	2	U	FD	2	w	1	d	JV	B	MOR	MORT	NR	17.0		77
22	Van Vleet et al., 1981	80	Duck (*Anas sp.)*	3	U	FD	15	d	1	d	JV	M	MOR	MORT	WO	15.0		77
23	Ling et al., 1979	6666	Chicken *(Gallus domesticus)*	4	U	FD	3	w	1	d	JV	M	MOR	SURV	WO	22.0		72
24	Van Vleet et al., 1981	80	Duck (*Anas sp.)*	2	U	FD	28	d	1	d	JV	M	MOR	MORT	WO		38.0	77

B = both; BIO = biochemical; BL = blood; BDWT = body weight changes; BEH = behavior; bw = body weight; d = days; F = female; FCNS = food consumption; FD = food; g = grams; GLSN = gross lesions; GRO = growth; HE = heart; HMCT = hematocrit; IM = immature; JV = juvenile; kg = kilograms; LOAEL = lowest-observed adverse effect level; M = male; M = measured; MB = muscle and bone; mg = milligrams; MOR = effects on mortality and survival; MORT = mortality; NOAEL = No-Observed Advese Effect Level; NR = Not reported; ORWT = organ weight changes; PTH = pathology; SURV = survival; U = unmeasured; w = weeks; WO = whole organism.

Figure 5.1 Avian TRV Derivation for Cobalt





Wildlife TRV Derivation Process

1) There are at least three results available for two test species within the growth and survival effect groups. There are enough data to derive TRV. There is no data available on reproductive effects in avian species.

2) There are are at least three NOAEL results available for calculation of a geometric mean.

3) The geometric mean of the NOAEL values for growth equals 7.61 mg cobalt/kg bw/day.

4) The geometric mean NOAEL value is lower than the lowest bounded LOAEL for growth or survival results.

5) The avian wildlife TRV for cobalt is equal to 7.61 mg cobalt/kg bw/day which is the geometric mean of the NOAEL values for growth.

Table 5.2 Calculation of the Avian Eco-SSLs for Cobalt					
Surrogate Receptor Group	**TRV for Cobalt (mg dw/kg bw/d)** [1]	**Food Ingestion Rate (FIR)**[2] **(kg dw/kg bw/d)**	**Soil Ingestion as Proportion of Diet (P_s)**[2]	**Concentration of Cobalt in Biota Type (i)**[2,3] **(B_i) (mg/kg dw)**	**Eco-SSL (mg/kg dw)**[4]
Avian herbivore (dove)	7.61	0.190	0.139	B_i = 0.0075 * $Soil_j$ where i = plants	270
Avian ground insectivore (woodcock)	7.61	0.214	0.164	B_i = 0.122 * $Soil_j$ where i = earthworms	120
Avian carnivore (hawk)	7.61	0.0353	0.057	$\ln(B_i)$ = 1.307 * $\ln(Soil_j)$ - 4.4669 where i = mammals	1300

[1] The process for derivation of wildlife TRVs is described in Attachment 4-5 of U.S. EPA (2003).
[2] Parameters (FIR, P_s, 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 * ($Soil_j$ * P_s + B_i) / TRV) solved for HQ=1 where $Soil_j$ = Eco-SSL (Equation 4-2; U.S. EPA, 2003).
NA = Not Applicable

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 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 530 papers with possible toxicity data for cobalt for either avian or mammalian test species. Of these studies, 498 were rejected for use as described in Section 7.5. Of the remaining papers, 20 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 in Appendix 6.1.

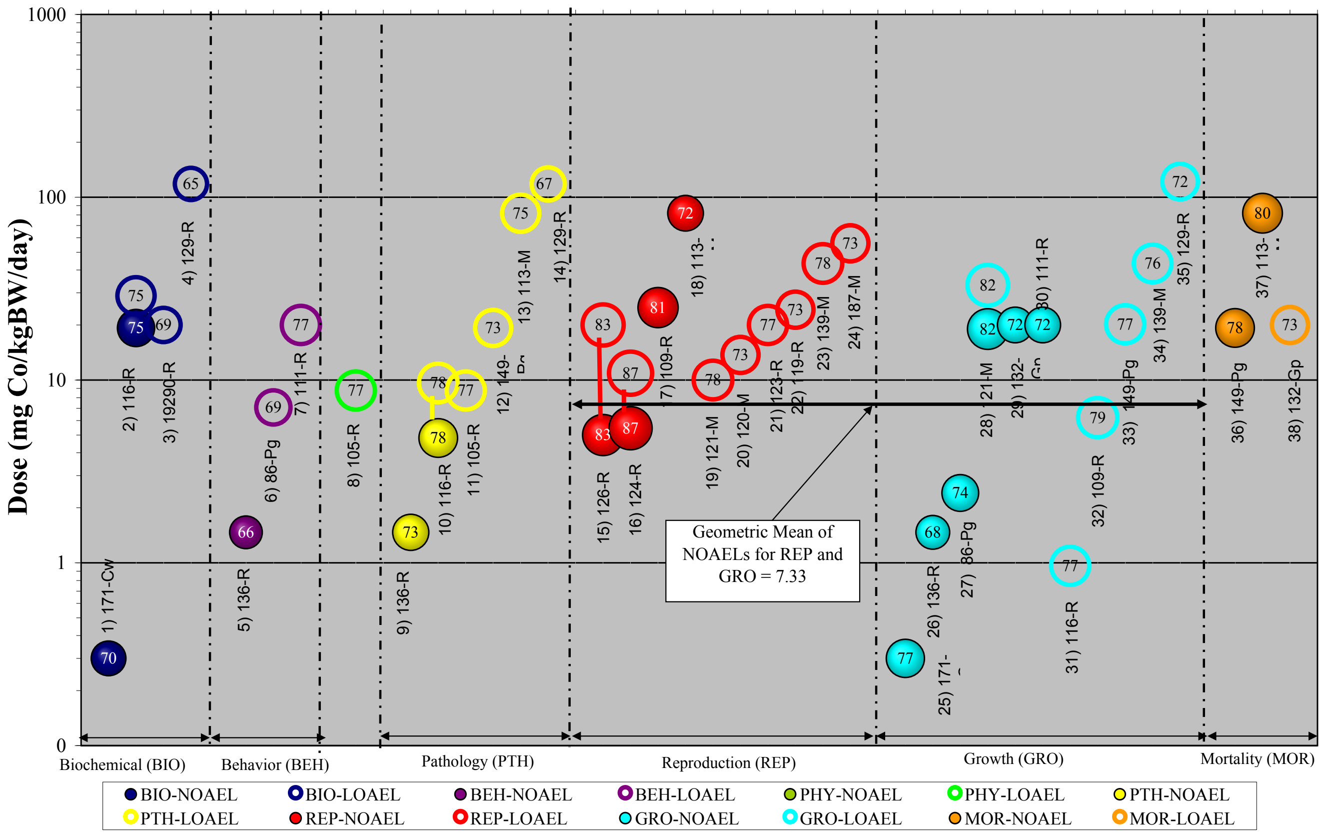
Within the 20 papers there are 38 results for biochemical (BIO), behavioral (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) endpoints with a total Data Evaluation Score >65 that were used to derive the TRV (U.S. EPA 2003; Attachment 4-3). These data are plotted in Figure 6.1 and correspond directly with the data presented in Table 6.1. The NOAEL values for growth and reproduction are used to calculate a geometric mean NOAEL. This result is examined in relationship to the lowest bounded LOAEL for reproduction, growth and survival to derive the TRV according to procedures in the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-4).

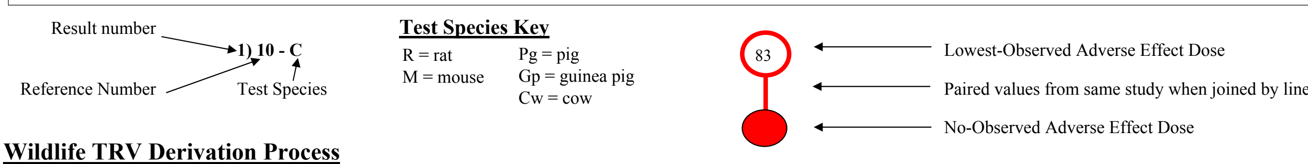
Table 6.1 Mammalian Toxiicty Data Extracted for Wildlife Toxicity Reference Value (TRV)
Cobalt
Page 1 of 1

Result #	Reference	Ref No.	Test Organism	# of Conc/ Doses	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	General Effect Group	Effect Measure	Response Site	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Evaluation Score
Biochemical																		
1	Maro et al., 1980	171	Cow (*Bos taurus*)	2	M	FD	45	d	7	mo	JV	F	BIO	HMGL	BL	0.300		70
2	Chetty et al., 1979	116	Rat (*Rattus norvegicus*)	6	U	FD	4	w	NR	NR	NR	B	BIO	HMGL	BL	19.3	28.9	75
3	Kadiiska et al., 1985	19290	Rat (*R. norvegicus*)	2	U	DR	30	d	NR	NR	JV	M	BIO	P450	LI		20.0	69
4	Derr et al., 1970	129	Rat (*R. norvegicus*)	2	U	DR	35	d	NR	NR	JV	M	BIO	HMCT	BL		118	65
Behavior																		
5	Gershbein et al., 1983	136	Rat (*R. norvegicus*)	2	U	FD	80	d	44	d	JV	M	BEH	NMVM	WO	1.47		66
6	Huck and Clawson, 1976	86	Pig (*Sus scrofa)*	4	U	FD	28	d	NR	NR	NR	NR	BEH	FCNS	WO		7.08	69
7	Bourg et al., 1985	111	Rat (*R. norvegicus*)	2	M	DR	57	d	80	d	JV	M	BEH	ACTP	WO		20.0	77
Physiology																		
8	Haga et al., 1996	105	Rat (*R. norvegicus*)	2	U	FD	16	w	NR	NR	NR	M	PHY	Other	HE		8.76	77
Pathology																		
9	Gershbein et al., 1983	136	Rat (*R. norvegicus*)	2	U	FD	80	d	44	d	JV	M	PTH	GHIS	NR	1.47		73
10	Chetty et al., 1979	116	Rat (*R. norvegicus*)	6	U	FD	4	w	NR	NR	NR	B	PTH	SMIX	TS	4.81	9.63	78
11	Haga et al., 1996	105	Rat (*R. norvegicus*)	2	U	FD	16	w	NR	NR	NR	M	PTH	BDWT	WO		8.76	77
12	Van Vleet et al., 1981	149	Pig (*S. scrofa)*	2	U	FD	10	w	NR	NR	JV	M	PTH	GLSN	HE		19.3	73
13	Seidenberg et al., 1986	113	Mouse (*Mus musculus*)	2	U	GV	5	d	NR	NR	GE	F	PTH	BDWT	WO		81.7	75
14	Derr et al., 1970	129	Rat (*R. norvegicus*)	2	U	DR	35	d	NR	NR	JV	M	PTH	SMIX	HE		118	67
Reproduction																		
15	Nation et al., 1983	126	Rat (*R. norvegicus*)	3	U	FD	69	d	80	d	MA	M	REP	TEWT	TE	5.00	20.0	83
16	Domingo et al., 1985	124	Rat (*R. norvegicus*)	4	U	GV	28	d	NR	NR	MA	F	REP	PRWT	WO	5.45	10.9	87
17	Paternain et al., 1988	109	Rat (*R. norvegicus*)	4	U	GV	9	d	NR	NR	GE	F	REP	PRWT	WO	24.9		81
18	Seidenberg et al., 1986	113	Mouse (*M. musculus*)	2	U	GV	5	d	NR	NR	GE	F	REP	PROG	WO	81.7		72
19	Pedigo et al., 1988	121	Mouse (*M. musculus*)	4	U	DR	13	w	12	w	SM	M	REP	RSUC	WO		10.0	78
20	Anderson et al., 1992	120	Mouse (*M. musculus*)	2	U	DR	9	w	12	w	MA	M	REP	TEWT	TE		13.7	73
21	Corrier et al., 1985	123	Rat (*R. norvegicus*)	2	U	FD	70	d	100	d	SM	M	REP	TEDG	TE		20.0	77
22	Mollenhauer et al., 1985	119	Rat (*R. norvegicus*)	2	U	FD	98	d	100	d	MA	M	REP	TEWT	TE		24.2	73
23	Anderson et al., 1993	139	Mouse (*M. musculus*)	2	U	DR	13	w	12	w	MA	M	REP	TEWT	TE		43.4	78
24	Pedigo et al., 1993	187	Mouse (*M. musculus*)	2	U	DR	10	w	8 to 10	w	JV	M	REP	PRFM	WO		55.9	73
Growth																		
25	Maro et al., 1980	171	Cow (*Bos taurus*)	2	M	FD	45	d	7	mo	JV	F	GRO	BDWT	WO	0.300		77
26	Gershbein et al., 1983	136	Rat (*R. norvegicus*)	2	U	FD	80	d	44	d	JV	M	GRO	BDWT	WO	1.47		68
27	Huck and Clawson, 1976	86	Pig (*S. scrofa)*	4	U	FD	16	w	NR	NR	NR	NR	GRO	BDWT	WO	2.41		74
28	Pedigo et al., 1988	121	Mouse (*M. musculus*)	4	U	DR	5	w	12	w	SM	M	GRO	BDWT	WO	19.0	33.0	82
29	Mohiuddin et al., 1970	132	Guinea pig (*Cavia porcellus*	2	U	OR	5	w	NR	NR	MA	M	GRO	BDWT	WO	20.0		72
30	Bourg et al., 1985	111	Rat (*R. norvegicus*)	2	M	DR	57	d	80	d	JV	M	GRO	BDWT	WO	20.0		72
31	Chetty et al., 1979	116	Rat (*R. norvegicus*)	6	U	FD	4	w	NR	NR	NR	B	GRO	BDWT	WO		0.963	77
32	Paternain et al., 1988	109	Rat (*R. norvegicus*)	4	U	GV	9	d	NR	NR	GE	F	GRO	BDWT	WO		6.23	79
33	Van Vleet et al., 1981	149	Pig (*Sus scrofa)*	2	U	FD	5	w	NR	NR	JV	M	GRO	BDWT	WO		20.2	77
34	Anderson et al., 1993	139	Mouse (*M. musculus*)	2	U	DR	13	w	12	w	MA	M	GRO	BDWT	WO		43.4	76
35	Derr et al., 1970	129	Rat (*R. norvegicus*)	2	U	DR	24	d	NR	NR	JV	M	GRO	BDWT	WO		122	72
Survival																		
36	Van Vleet et al., 1981	149	Pig (*S. scrofa)*	2	U	FD	10	w	NR	NR	JV	M	MOR	MORT	WO	19.3		78
37	Seidenberg et al., 1986	113	Mouse (*M. musculus*)	2	U	GV	5	d	NR	NR	GE	F	MOR	MORT	WO	81.7		80
38	Mohiuddin et al., 1970	132	Guinea pig (*Cavia porcellus*	2	U	OR	5	w	NR	NR	MA	M	MOR	SURV	WO		20.0	73

ACTP = activity level; B = both;BDWT = body weight changes; BEH = behavior; BIO = biochemical; BL = blood; d = days; DR = Drinking water; F = female; FCNS = food consumption; FD = food; GE = gestation; GHIS = histologic; GLSN = gross lesions; GRO = growth; GV = gavage; HE = heart; HMCT = hematocrit; HMGL = hemoglobin; JV = juvenile; LI = liver; M = male; M = measured; MA = mature; mo = months; MOR = mortality, MORT = Mortality; NMVM = number of movements; NR = Not reported; OR = other oral; P450 = changes in cytochrome P450; PHY = physiology; PTH = pathology; PRFM = sexual performance; PROG = progeny count ; PRWT = progeny weight; REP = reproduction; RSUC = reproductive success; SM = sexually mature; SMIX = weight relative to body weight; SURV = survival; TE = testes; TEDG = testes degeneration; TEWT = testes weight; TS = Thymus; U = unmeasured; w = weeks; WO = whole organism

Figure 6.1 Mammalian TRV Derivation for Cobalt





Wildlife TRV Derivation Process

1) There are at least three results available for two test species within the growth, reproduction and survival effect groups. There are enough data to derive TRV.

2) There are are at least three NOAEL results available for calculation of a geometric mean.

3) The geometric mean of the NOAEL values for growth and reproduction equals 7.33 mg cobalt/kg BW/day.

4) The geometric mean NOAEL value is less than the lowest bounded LOAEL for reproduction, growth, or survival.

5) The mammalian wildlife TRV for cobalt is equal to 7.33 mg cobalt/kg BW/day.

A geometric mean of the NOAEL values for growth and reproduction was calculated at 7.33 mg cobalt/kg bw/day. This value is lower than the lowest bounded LOAEL for either reproductive, growth, or survival results. Therefore, the TRV is equal to the geometric mean of the NOAEL values for reproduction and growth at 7.33 mg cobalt/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 each for three surrogate species representing different trophic groups. The mammalian Eco-SSLs for cobalt are calculated according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5) and are summarized in Table 6.2

Table 6.2 Calculation of the Mammalian Eco-SSLs for Cobalt

Surrogate Receptor Group	TRV for Cobalt (mg dw/kg bw/d) [1]	Food Ingestion Rate (FIR)[2] (kg dw/kg bw/d)	Soil Ingestion as Proportion of Diet (P_s)[2]	Concentration of Cobalt in Biota Type (i)[2,3] (B_i) (mg/kg dw)	Eco-SSL (mg/kg dw)[4]
Mammalian herbivore (vole)	7.33	0.0875	0.032	$B_i = 0.0075 * Soil_j$ where i = plants	2100
Mammalian ground insectivore (shrew)	7.33	0.209	0.030	$B_i = 0.122 * Soil_j$ where i = earthworms	230
Mammalian carnivore (weasel)	7.33	0.130	0.043	$\ln(B_i) = 1.307 * \ln(Soil_j) - 4.4669$ where i = mammals	470

[1] The process for derivation of wildlife TRVs is described in Attachment 4-5 of U.S. EPA (2003).
[2] Parameters (FIR, P_s, 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] $HQ = FIR * (Soil_j * P_s + B_i) / TRV$) solved for HQ=1 where $Soil_j$ = Eco-SSL (Equation 4-2; U.S. EPA, 2003).
NA = Not Applicable

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7.0 REFERENCES

7.1 General Cobalt References

Diaz, G. J., R. J. Julian, and E. J. Squires. 1994a. Cobalt-induced polycythaemia causing right ventricular hypertrophy and ascites in meat-type chickens. *Avian Pathology.* 91-104.

Diaz, G. J., R. J. Julian, and E. J. Squires. 1994b. Lesions in broiler chickens following experimental intoxication with cobalt. *Avian Dis.* 38 (2): 308-16.

Haga, Y., N. Clyne, N. Hatroi, C. Hoffman-Bang, S. K. Pehrsson, and L. Ryden. 1996. Impaired myocardial function following chronic cobalt exposure in an isolated rat heart model. *Trace Elements and Electrolytes*. 13 (2): 69-74.

Henry, P. 1995. Copper Bioavailability. Chapter 6. In: *Bioavailability of Nutrients for Animals: Amino Acids, Minerals, and Vitamins* . C. Ammerman, D. Baker, and A. Lewis (eds.), Academic Press. San Diego, CA.

Paternain, J. L., J. L. Domingo, and J. Corbella. 1988. Developmental toxicity of cobalt in the rat. *J Toxicol Environm Health*. 24 (2): 193-200.

Pedigo, N. G. and M. W. Vernon. 1993. Embryonic losses after 10-week administration of cobalt to male mice. *Reprod Toxicol.* 7: 111-116.

United States Environmental Protection Agency (U.S. EPA). 2003. *Guidance for Developing Ecological Soil Screening Levels*. November. Office of Solid Waste and Emergency and Remedial Response. OSWER Directive 9285.7-55

United States Environmental Protection Agency (U.S. EPA). 1999. *Ecological Risk Assessment and Risk Management Principles for Superfund Sites*. Office of Emergency and Remedial Response, Washington, DC. OSWER Directive 9285.7-28.P.

United States Environmental Protection Agency (U.S. EPA). 1998. *Guidelines for Ecological Risk Assessment*. Risk Assessment Forum. U.S. Environmental Protection Agency, Washington DC. EPA/630/R-95/002F. April. May 14, 1998 Federal Register 63(93): 26846-26924.

United States Environmental Protection Agency (U.S. EPA). 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* Interim Final. U.S. Environmental Protection Agency, Environmental Response Team (Edison, NJ). June 5, 1997.

7.2 References Used for Derivation of Plant and Soil Invertebrate Eco-SSLs

Rehab, F. I. and Wallace, A. 1978. Excess Trace Metal Effects on Cotton: 2. Copper, Zinc, Cobalt and Manganese in Yolo Loam Soil. *Commun. Soil Sci. Plant Anal*. 9[6]: 519-527.

TN&Associates Inc. 2000. *Plant Toxicity Testing to Support Development of Ecological Soil Screening Levels*. Subcontract Agreement No.SC-IDIQ-1999142-29, National Center for Environ.Assess., Washington, D.C. 53 p.

7.3 References Rejected for Use in Derivation of 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.

No Dose	Abdel-Sabour, M. F., El Naggr, H. A., and Suliman, S. M. 1994. Use of Inorganic and Organic Compounds as Decontaminants for Cobalt T-60 and Cesium-134 by Clover Plant Grown on INSHAS Sandy Soil. Govt Reports Announcements & Index (GRA&I) 15, 17 p.
Mix	Abou Hussien, E. A. and Faiyad, M. N. 1996. The Combined Effect of Poudrette, Zinc and Cobalt on Corn Growth and Nutrients Uptake in Alluvial Soils. *Egypt. J. Soil Sci*. 36[1-4], 47-58.
No Control	Adams, S. N. and Honeysett, J. L. 1964. Some Effects of Soil Waterlogging on the Cobalt and Copper Status of Pasture Plants Grown in Pots. Aust.J.Agric.Res. 15, 357-367
OM, pH	Adams, S. N., Honeysett, J. L., Tiller, K. G., and Norrish, K. 1969. Factors Controlling the Increase of Cobalt in Plants Following the Addition of a Cobalt Fertilizer 38333. Aust.J.Soil Res. 7, 29-42
No Dose	Agarwala, S. C., Bisht, S. S., and Sharma, C. P. 1977. Relative Effectiveness of Certain Heavy Metals in Producing Toxicity and Symptoms of Iron Deficiency in Barley. Can J Bot 55, 1299-1307
Media	Ahmed, M. B. and Twyman, E. S. 1953. The Relative Toxicity of Manganese and Cobalt to the Tomato Plant. J.Exp.Bot.(London) 4[11], 164-172
Media	Ahmed, S. and Evans, H. J. 1959. Effect of Cobalt on the Growth of the Soybeans in the Absence of Supplied Nitrogen. Biochem.Biophys.Res.Comm. 1[5], 271-275
Media	Ahmed, S. and Evans, H. J. 1960. Cobalt: A Micronutrient Element for the Growth of Soybean Platns Under Symbiotic Conditions. Soil Sci 90, 205-210
Mix	Alberici, T. M., Sopper, W. E., Storm, G. L., and Yahner, R. H. 1989. Trace Metals in Soil Vegetation and Voles from Mine Land Treated with Sewage Sludge. J Environ Qual 18, 115-120
Mix	Alegria, A., Barbera, R., Boluda, R., Errecalde, F., Farre, R., and Lagarda, M. J. 1992. Relationship Between Cobalt, Copper and Zinc Content of Soils and Vegetables. Nahrung 36[5], 451-460
FL	Aleshin, E. P., Sheudzhen, A. K., Doseeva, O. A., and Rymar, V. T. 1987. Photosynthetic and Respiratory Activity in Rice Leaves as a Function of Cobalt Supply to the Plants. Dokl.Vses.Akad.Sel'skokhoz.Nauk 2, 15-17
Media	Amir, Hamid and Pineau, Rene. 1998. Effects of metals on the germination and growth of fungal isolates from new caledonian ultramafic soils. Soil Biology & Biochemistry 30[14], 2043-2054
Mix	Anderson, A. J., Meyer, D. R., and Mayer, F. K. 1973. Heavy Metal Toxicities: Levels of Nickel, Cobalt, and Chromium in the Soil and Plants Associated with Visual Symptoms and Variation in Growth of an Oat Crop. Aust.J.Agric.Res. 24, 557-571.
Mix	Andreae, H. Verteilung Von Schwermetallen In Einem Forstlich Genutzten Wassereinzugsgebiet Unter Dem Einfluss Saurer Deposition Am Beispiel Der Soesemulde (Westharz). (Distribution Of

Heavy Metals In A Wood Culture Water Catchment Area Under The Influence Of Acid De. Govt-Reports-Announcements-&-Index-(GRA&I),-Issue-21,-1995.

OM, pH Askew, H. O. and Dixon, J. K. 1937. Influence of Cobalt Top-Dressing on the Cobalt Status of Pasture Plants. N.Z.J.Sci.Technol. 18, 688-693

FL Astapovich, N. I. and Grel, M. V. 1975. Effects of Various Cobalt Salts and Their Concentrations on the Activity of Pectolytic Enzymes Systemized by Microscopic Fungi. Biol.Akt.Veshchestva Mikroorg. 36-39.

FL Austenfeld, F. A. 1979. Effects of Nickel, Cobalt and Chromium on Net Photosynthesis of Primary and Secondary Leaves of Phaseolus vulgaris L. (Nettophotosynthese der Primarund Folgeblatter von Phaseolus vulgaris L. unter dem Einfluss von Nickel, Kobalt und Chrom). Photosynthetica 13[4], 434-438.

Media Baker, A. J. M., Brooks, R. R., Pease, A. J., and Malaisse, F. 1983. Studies on Copper and Cobalt Tolerance in Three Closely Related Taxa Within the Genus Silene L. (Caryophyllaceae) from Zaire. Plant Soil 73, 377-385.

Media Barker, A. V. and Corey, K. A. 1991. Interrelationships of ammonium toxicity and ethylene action in tomato. Hortscience. 26[2], 177-180.

Media Berry, W. L. 1978. Comparative Toxicity of VO3, CrO2-4, Ni2+, Cu2+, Zn2+, and Cd2+ to Lettuce Seedlings. In: D.C.Adriano and I.L.Brisbin,Jr.(Eds.), Environmental Cemistry and Cycling Processes, Proc.Symp.Held at Augusta, Georgia, April 18-May 1, 1976, Tech.Info.Center, U.S.Dep of Energy (U.S.NTIS CONF-760429) , 582-589.

Media Bittell, J., Koeppe, D. E., and Miller, R. J. 1974. Sorption of Heavy Metals Cations by corn Mitochondria and the Effects on Electron and Energy Transfer Reactions. Physiol Plant 30, 226-230.

Species Blankenship, M. L. and Wilbur, K. M. 1975. Cobalt Effects on Cell Division and Calcium Uptake in the Coccolithophoroid *Cricosphaera carterae* (Haptophyceae) 38589. J.Physiol. 11, 211-219.

Media Bobak, M. 1974. Influence of Exogenous Added Cobalt upon the Submicroscopic Structure and the Chromosomes of Meristematic Cells of the Horse Bean (Vicia faba L.,C.V. Zborovicky). Physiol.Plant. 8, 17-24.

Media Bolle-Jones, E. W. and Mallikarjuneswara, V. R. 1957. A Beneficial Effect of Cobalt on the Growth of the Rubber Plant (Hevea brasiliensis). Nature 179, 738-739.

Rev Bozhenkov, V. P. 1968. Effect of Aluminum and Cobalt on the Nucleic Acid Content and Ribonuclease Acitivty in the Growth Points of Sunflower Under Water Deficit Conditions 37728. *Russ.J.Plant Physiol.*(Transl.of Fiziol.Rast.15(1):116-122) 68, 94-99.

Media Brenchley, W. E. 1938. Comparative Effects of Cobalt, Nickel and Copper on Plant Growth. Ann.Appl.Biol. 25[4], 671-694.

Dup Brenchley, W. E. 1938. Comparative Effects of Cobalt, Nickel, and Copper on Plant Growth 40004. *Ann.Appl.Biol*. 25[4], 671-694.

No Control Brooks, R. R. 1977. Copper and Cobalt Uptake by Haumaniastrum Species. Plant Soil 48, 541-544.

Rev	Brooks, R. R., Reeves, R. D., Morrison, R. S., and Malaisse, F. 1980. Hyperaccumulation of Copper and Cobalt: A Review. Bull.Soc.R.Bot.Belgique 113, 166-172.
FL	Burca, S., Cachita-Cosma, D., Craciun, C., and Trifu, M. 1984. Modifications Caused by the Trace Elements Manganese and Cobalt in the Ultrastructure of the Roots of Tomato Seedlings (Modificari Cauzate de Microelementele Mangansi Cobalt in Ultrastructura Radacinilor Plantulelor de Tomate). Stud.Univ.Babes-Bolyai.Biol. 29, 27-34.
No Dose	Cataldo, D. A. and Wildung, R. E. 1978. Soil and Plant Factors Influencing the Accumulation of Heavy Metals by Plants. *Environ.Health Perspect*. 27, 149-159.
No Dose	Cataldo, D. A., Fellows, R. J., and Harvey, S. D. 1996. Evaluation of the Metabolic Fate of Munitions Material (TNT RDX) in Plant Systems and Initial Assessment of Material Interaction with Plant Genetic Material. Govt Reports Announcements & Index (GRA&I), (8):
FL	Celardin, F. and Landry, J. C. 1988. Bioindicators of pollution earthworms and heavy metals in soil. ARCH SCI (GENEVA).Archives des Sciences (Geneva).41 (2).1988.225-228. 41[2], 225-228.
No Dose	Chatterjee, J. and Chatterjee, C. 2000. Phytotoxicity of Cobalt, Chromium and Copper in Cauliflower. Environ.Pollut. 109[1], 69-74.
No Tox	Clapp, R. B. Annual Report Of The Environmental Restoration Monitoring And Assessment Program At Oak Ridge National Laboratory For Fy 1992. Environmental Restoration Program. Govt-Reports-Announcements-&-Index-(GRA&I),-Issue-09,-1993.
Media	Clark, R. B., Pier, P. A., Knudsen, D., and Maranville, J. W. 1981. Effect of Trace Element Deficiencies and Excesses on Mineral Nutrients in Sorghum. J.Plant Nutr. 3[1-4], 357-374.
Rev	Cole, C. J. and Carson, B. L. 1981. Cobalt in the Food Chain. In: I.C.Smith, and B.L.Carson (Eds.), Trace Metals inthe Environment, Volume 6, Cobalt, Ann Arbor Science Publ.Inc., Ann Arbor, MI , 777-924.
No Control	Crossley, D. A. J., Blood, E. R., Hendrix, P. F., and Seastedt, T. R. 1995. Turnover of Cobalt-60 by Earthworms (Eisenia foetida) (Lumbricidae, Oligochaeta). Appl.Soil Ecol. 2[2], 71-75.
FL	Danilova, T. A. and Demkina, E. N. 1967. The Role of Cobalt in Nitrogen Accumulation by Leguminosae. Dokl.Akad.Nauk 172[2], 487-490.
FL	Danilova, T. A., Tishchenko, I. V., and Demikina, E. N. 1969. Some Characteristic Effects of Cobalt on Peas. Agrokhimiya 1, 85-89.
Media	Dekock, P. C. 1956. Heavy Metal Toxicity and Iron Chlorosis. Ann.Bot. 20[77], 133-141.
Media	Doncheva, S. 1992. Qualitative and structural changes in maize plant root cells under increased concentrations of manganese and cobalt. Dokl.Bulg.Akad.Nauk. 45[8], 119-122.
OM, pH	Fischer, Erno and Molnar, Laszlo. 1997. Growth and reproduction of Eisenia fetida (oligochaeta, lumbricidae) in semi-natural soil containing various metal chlorides. Soil Biol Biochem 29[3/4], 667-670.
Media	Gabbrielli, R., Mattioni, C., and Vergnano, O. 1991. Accumulation Mechanisms and Heavy Metal Tolerance of a Nickel Hyperaccumulator. J.Plant Nutr. 14[10], 1067-1080.

Media Gerendas, J., Polacco, J. C., Freyermuth, S. K., and Sattelmacher, B. 1998. Co does not replace Ni with respect to urease activity in zucchini (Cucurbita pepo convar. giromontiina) and Soybean (Glycine max). Plant Soil 203[1], 127-135.

No Control Gerzabek, M. H., Mohamad, S. A., Mueck, K., and Horak, O. 1994. 60Co, 63Ni and 94Nb Soil-to-Plant Transfer in Pot Experiments. J.Environ.Radioact. 25, 205-212.

No Dur Gheesling, S. E., Gideon, J. C., Gregory, S. M., Hamilton, L. V., and Horwedel, B. M. Environmental Surveillance Data Report For The First Quarter Of 1993. Govt-Reports-Announcements-&-Index-(GRA&I),-Issue-16,-1994.

No Dur Gheesling, S. E., Gideon, J. C., Gregory, S. M., Hamilton, L. V., and Loffman, R. S. Environmental Surveillance Data Report For The Second Quarter Of 1993. Govt-Reports-Announcements-&-Index-(GRA&I),-Issue-15,-1994.

FL Godnev, T. N. and Leshina, A. V. 1967. After Effects of Molybdenum and Cobalt on Peas. Dokl Akad.Nauk Beloruss. 11[4], 359-361.

No Dur Goldberg, P. Y., Cooper, R. C., Hamilton, L. V., Hughes, J. F., and Horwedel, B. M. Environmental Surveillance Data Report For The First Quarter Of 1992. Govt-Reports-Announcements-&-Index-(GRA&I),-Issue-15,-1993.

FL Gorid'ko, I. V. 1967. The Effect of Cobalt on Water Content, Water Retention, and Transporation of Potato Leaves. Nauchn.Dokl.Vyssh.Skh.Biol.Nauki 3, 84-87.

Media Gorsuch, J. W., Kringle, R. O., and Robillard, K. A. 1990. Chemical Effects on the Germination and Early Growth of Terrestrial Plants. In: W.Wang, J.W.Gorsuch., and W.R.Lower (Eds.), Plants for Toxicity Assessment, ASTM STP 1091, Philadelphia, PA , 49-58.

Media Grover, S. and Purves, W. K. 1976. Cobalt and Plant Development Interactions with Ethylene in Hypocotyl Growth. Plant Physiol. 57, 886-889.

Mix Grummitt, W. E. 1976. Transfer of Cobalt-60 to Plants from Soils Treated with Sewage Sludge. In: C.E.Cushing,Jr.(Ed.), Radioecology and Energy Resources, Dowden, Hutchinson, and Ross, Stroudsburg, PA , 331-335.

Media Halsall, D. M. 1977. Effects of Certain Cations on the Formation and Infectivity of Phytophthora Zoospores. 2. Effects of Copper, Boron, Cobalt, Manganese, Molybdenum, and Zinc Ions. Can.J.Microbiol. 23[8], 1002-1010.

Media Handreck, K. A. and Riceman, D. S. 1969. Cobalt Distribution in Several Pasture Species Grown in Culture Solution. Aust.J.Agric.Res. 20, 213-226.

Mix Hartenstein, R., Neuhauser, E. F., and Narahara, A. 1981. Effects of Heavy Metal and Other Elemental Additives to Activated Sludge on Growth of *Eisenia foetida*. *J. Environ. Qual.* 10[3], 372-376.

Mix Hewitt, E. J. and Bolle-Jones, E. W. 1951. Investigations on Possible Micronutrient Elements for Higher Plants. I. Experiments with Cobalt, Nickel and Gallium in Sand Culture. Ann.Rep.Agric.Hortic.Res.Sta., Long Ashton, Bristol, England , 62-66.

Species Hodgson, J. F. 1969. Effect of Iron Removal on Cobalt Sorption By Clays. Soil Sci. 108[6], 391-396.

Media Howard, B. and Simkiss, K. 1981. Metal Binding by Helix aspersa Blood. Comp Biochem Physiol 70A, 559-561.

Media Imai, I. and Siegel, S. M. 1973. A Specific Response to Toxic Cadmium Levels in Red Kidney Bean Embryos. Physiol.Plant. 29, 118-120.

FL Ishchenko, G. S. and Butnik, A. S. 1991. The influence of cobalt and cadmium on the growth, development and crops of the basic cultivated plants in central Asia. Uzb.Biol.Zh. [5], 30-33.

Media Jacobs, E. E., Jacob, M., Sanandi, D. R., and Bradley, L. B. 1956. Uncoupling of Oxidative Phosphorylation by Cadmium Ion. Journal of Biological Chemistry 223, 147-156.

Species Jardine, P. M. and Jacobs, G. K. 1991. Unsaturated Transport Of Inorganic Cations In Undisturbed Soil Columns. Gov.Rep.Announce.Index Issue 14.

Media Jarosik, J., Zvara, P., Konecny, J., and Obdrzalek, M. 1988. Dynamics of Cobalt-60 Uptake by Roots of Pea Plant (Pisum sativum). Sci.Total Environ. 71, 225-229.

Media Jaworska, M., Gorczyca, A., Sepiol, J., and Tomasik, P. 1997. Effect of Metal Ions on the Entomopathogenic Nematode Heterohabditis becteriophora poinar (Nematode: Heterohabditidae) Under Laboratory Conditions. Water Air Soil Pollut 93, 157-166.

FL Kalashnikova, E. V. Cobalt and cadmium accumulation in the yield of several crops in plant irradiation carried out on soils polluted with heavy metals. Agrokhimiya.Agrokhimiya.0 (9).1991.77-82.

FL Kamenova, S. M. Y., Kudrev, T. G., and Shakhpazova, L. K. A. 1983. Effect of Cobalt and Mercury on Some Maize Plant Reactions. Fiziol.Rast. 9, 78-82.

OM, pH Khan, M. R., Singh, S. K., and Khan, M. W. 1988. Response of Lentil to Cobalt as a Soil Pollutant. Ann.Appl.Biol. 112[Suppl], 104-105.

OM, pH Khan, M. R., Khan, M. W., and Nabi, S. T. 1994. Effect of cobalt, a soil-pollutant, on hatching, mortality and penetration of root-knot nematode, Meloidogyne incognita. Chem.Environ.Res. 3[3/4], 265-269.

OM, pH Khan, M. W. and Salam, M. A. 1990. Interactions of Meloidogyne-javanica Fusarium-udum and Rhizobium on pigeon pea in the presence of nickel and cobalt as pollutants. Ann.Appl.Biol. 116[3], 549-556.

Media Khan, Mujeebur Rahman, Khan, M. Wajid, and Singh, Kamal. 1996. Growth performance of chickpea under the influence of nickel and cobalt as soil pollutants. J.Indian Bot.Soc. 75[3/4], 193-196.

OM Kloke, A. and Egels, W. 1976. Effect of Excess Fertilization with Boron, Cobalt, Copper Manganese, and Zinc on the Content of These Elements in Soil and Plants 38813. Dokl.Zarub.Uchastnikov-Mezhdunar.Kongr.Miner.Udobr., 8th 2[4/5], 115-121.

Media Komczynski, L., Nowak, H., and Rejniak, L. 1963. Effect of Cobalt, Nickel and Iron on Mitosis in the Roots of the Broad Bean (Vicia faba). Nature 198[4884], 1016-1017.

No Control Kramer, James R., Adams, Nicholas W. H., Manolopoulos, Helen, and Collins, Pamela V. 1999. Silver at an old mining camp, Cobalt, Ontario, Canada. Environ.Toxicol.Chem. 18[1], 23-29.

OM, pH Kubota, J., Lemon, E. R., and Allaway, W. H. 1963. The Effect of Soil Moisture upon the Uptake of Molybdenum, Copper and Cobalt by Alsike Clover. Soil Sci.Soc.Am.Proc. 27, 679-683.

Media Lane, I. and Puckett, K. J. 1979. Responses of the Phosphatase Activity of the Lichen Cladina rangiferina to Various Environmental Factors Including Metals. Can.J.Bot. 57, 1534-1540.

FL Leshina, A. V. 1969. Effect of the Presowing Treatment of Seeds with Cobalt and Molybdenum Salts on Some Physiological and Biochemical Indexes of Leguminous Crops. Botanika 11, 179-183.

FL Lipskaya, G. A. 1970. Anatomo-Cytological Features of Cucumber Leaves in the Presence of Cobalt and Manganese in the Nutrient Mixture 37794. Fiziol.Rast. 17[5], 997-1003 (RUS)

FL Lipskaya, G. A. 1970. Accumulation of Chlorophyll in Sugar Beet Chloroplasts Under the Influence of Cobalt Applied Separately and Together with Boron, Manganese, Copper, Zinc, and Molybdenum. Agrokhimiya 2, 105-110

FL Lipskaya, G. A. 1971. Accumulation of Chlorophyll in Chloroplasts of Cucumber Leaves Under the Effect of Cobalt and Manganese Applied Separately and Together. Biol.Nauki 15[1], 14-2.

FL Lipskaya, G. A., Matvyeyentsava, V. S., and Sergeichik, S. A. 1972. Effect of Cobalt on Accumulation of Various Forms of Chlorophyll. Dokl.Akad.Nauk.B SSR 116, 70-72.

FL Lipskaya, G. A., Matvyeyentsava, V. S., and Charkaskaya, S. K. 1973. Effect of Various Combination of Cobalt with Other Trace Elements on the Change of Activity of the Hill Reaction. Vysti.Akad.Nauk.B.SSR Syer.Biyal.Navuk. 2[2], 32-36.

FL Lipskaya, G. A. 1974. Effect of Cobalt and Heteroauxin on the Morphology and Structure of a Barley Leaf. Vestsi Akad.Navuk Belaruski , Ser.Biyal.Navuk, No.2 , 121-123.

FL Lipskaya, G. A. 1988. Morphofunctional Characteristics of the Photosynthetic Apparatus of the Growing Barley Leaf Under the Effect of Cobalt and Auxin. Fiziol.Biokhim.Kul't.Rast. 20[3], 241-246.

FL Lipskaya, G. A. 1988. Effect of cobalt and auxin on morphological and functional characteristics of the photosynthetic apparatus of growing barley leaves. Fiziol.Biokhim.Kul't.Rast. 20[3], 241-245.

FL Lipskaya, G. A. 1990. Development of the Photosynthetic Apparatus in Barley Grown from Seeds Varied in Cobalt Content Under Sterile and Non-Sterile Conditions. Fiziol.Rast. 37[4], 668-674.

Media Lui, Donghua, Jiang, Wusheng, Wang, Wei, and Zhai, Lin. 1995. Evaluation of metal ion toxicity on root tip cells by the allium test. Israel Journal of Plant Sciences 43, 125-133.

OM McKenzie, R. M. 1978. The Effect of Two Manganese Dioxides on the Uptake of Lead, Cobalt, Nickel, Copper and Zinc by Subterranean Clover. Aust.J.Soil Res. 16[2], 209-214.

Mix Memon, A. R., Ito, S., and Yatazawa, M. 1980. Taxonomic Characteristics in Accumulating Cobalt and Nickel in the Temperate Forest Vegetation of Central Japan. Soil Sci.Plant Nutr. 26[2], 271-280.

Media Millikan, C. R. 1948. Effect of Molybdenum on the Severity of Toxicity Symptoms in Flax Induced by an Excess of Either Manganese, Zinc, Copper, Nickel or Cobalt in the Nutrient Solution. J.Aust.Inst.Agric.Sci. 5, 180-186.

Media Millikan, C. R. 1949. Effects of Flax of a Toxic Concentration of Boron Iron, Molybenum, Aluminum, Copper, Zinc, Cobalt, or Nickel in the Nutrient Solution. R Soc Victoria Proc 61, 25-42.

No Control Mitchell, R. L. 1945. Cobalt and Nickel in Soils and Plants. Soil Sci. 60, 63-70.

Media Moreno-Caselles, J., Perez-Espinosa, A., Perez-Murcia, M. D., Moral, R., and Gomez, I. 1997. Effect of Increased Cobalt Treatments on Cobalt Concentration and Growth of Tomato Plants. J.Plant Nutr. 20[7/8], 805-811.

Media Moreno-Caselles, J., Perez-Espinosa, A., Perez-Murcia, M. D., Moral, R., and Gomez, I. 1998. Cobalt-Induced Stress in Soilless Lettuce Cultivation: I. Effect on Yield and Pollutant Accumulation. Acta Hortic. 458, 239-242.

Media Moreno-Caselles, J., Perez-Espinosa, A., Perez-Murcia, M. D., Moral, R., and Gomez, I. 1998. Cobalt-induced stress in soilless lettuce cultivation: II. Effect on nutrient evolution. Acta Hortic., V458, NWater Quality and Quantity in Greenhouse Horticulture , 243-246.

No Control Morrison, R. S., Brooks, R. R., Reeves, R. D., and Malaisse, F. 1979. Copper and Cobalt Uptake by Metallophytes from Zaire. Plant Soil 53, 535-539.

OM, pH Neuhauser, E. F., Meyer, J., Malecki, M. R., and Thomas, J. M. 1984. Impact of Dietary Cobalt Supplements on Growth and Reproduction in the Earthworm Eisenia foetida. Soil Biol Biochem 16[5], 521-523.

Score Nicholas, D. J. D. 1950. Some Effects of Metals in Excess on Crop Plants Grown in Soil Culture. I. Effects of Copper, Zinc, Lead, Cobalt, Nickel and Manganese on Tomato Grown in an Acid Soil. *Bristol Agric.Hortic.Res.Stn.Annu.Rep*. 1950 , 96-108.

Media Okamoto, K., Suzuki, M., Fukanim, M., Toda, S., and Fuwa, K. 1977. Heavy Metal Tolerance of Penicillium Ochro-Chloron II. Uptake of Heavy Metals by Copper Tolerant Fungus Penicillium Ochro-Chloron. Agric.Biol.Chem. 41, 17-22.

Media Paliouris, G. and Hutchinson, T. 1991. Arsenic, Cobalt and Nickel Tolerances in Two Populations of Silene vulgaris (Moench) Garcke from Ontario, Canada. New Phytol. 117, 449-459.

Rev Palit, S., Sharma, A., and Talukder, G. 1994. Effects of Cobalt on Plants. Bot.Rev. 60[2], 149-181.

Media Patel, P. M., Wallace, A., and Mueller, R. T. 1976. Some Effects of Copper, Cobalt, Cadmium, Zinc, Nickel, and Chromium on Growth and Mineral Element Concentration in Chrysanthemum. J.Am.Soc.Hortic.Sci. 101[5], 553-556.

OM, pH Patterson III, W. A. and Olson, J. J. 1982. Effects of Heavy Metals on Radicle Growth of Selected Woody Species Germinated on Filter Paper, Mineral and Organic Soil Substrates. Can J For Res 13, 233-238.

OM Patterson III, W. A. and Olson, J. J. 1983. Effects of Heavy Metals on Radicle Growth of Selected Woody Species Germinated on Filter Paper, Mineral and Organic Soil Substrates. Can.J.For.Res. 13, 233-238.

Score Perez-Espinosa, A., Moreno-Caselles, J., Moral, R., Perez-Murcia, M. D., and Gomez, I. 1999. Effect of Sewage Sludge and Cobalt Treatments on Tomato Fruit Yield, Weight and Quality. *J. Plant Nutr*. 22[2]: 379-385.

FL Poletaeva, V. F. 1969. Effect of Cobalt on Fusarium Cotton Wilt. Izv.Akad.Nauk Turkm.SSR, Ser.Biol.Nauk, 71[3], 73-74.

Media Puckett, K. J., Nieboer, E., Gorzynski, M. J., and Richardson, D. H. S. 1973. The Uptake of Metal Ions by Lichens: A Modified Ion-Exchange Process. New Phytol 72, 329-342.

Media Rauser, W. E. 1978. Early Effects of Phytotoxic Burdens of Cadmium, Cobalt, Nickel and Zinc in White Beans. Can.J.Bot. 56, 1744-1749.

Media Rauser, W. E. and Dumbroff, E. B. 1981. Effects of Excess Cobalt, Nickel and Zinc on the Water Relations of Phaseolus vulgaris. Environ.Exp.Bot. 21[2], 249-255.

Media Reisenauer, H. M. 1960. Cobalt in Nitrogen Fixation by a Legume. Nature (London) 186[4722], 375-376.

Media Reisenauer, H. M. 1960. Cobalt in Nitrogen Fixation by a Legume. Nature 186, 375-376.

No Control Romney, E. M. and Toth, S. J. 1954. Plant and Soil Studies with Radioactive Manganese. Soil Sci. 77, 107-117.

No COC Rosolem, C. A. and Caires, E. F. 1998. Yield and Nitrogen Uptake of Peanuts as Affected by Lime, Cobalt, and Molybdenum. J.Plant Nutr. 21[5], 827-835.

OM Rossiter, R. C., Curnow, D. H., and Underwood, E. J. 1948. The Effect of Cobalt Sulphate on the Cobalt Content of Subterranean Clover (Trifolium subterraneum L. var. Dwalganup) at Three Stages of Growth 20464. J.Aust.Inst.Agric.Sci. 14[1], 9-14.

Mix Sanglimsuwan, Sarunya, Yoshida, Naoto, Morinaga, Tsutomu, and Murooka, Yoshikatsu. 1993. Resistance to and uptake of heavy metals in mushrooms. Journal of Fermentation and Bioengineering 75[2], 112-114.

Media Sarada, R. L. and Polasa, H. 1992. Effect of Manganese, Copper and Cobalt on the In Vitro Growth of R. leguminosarum-2001 and on the Symbiotic Nitrogen Fixation in Lentil Plants. Indian J.Agric.Res. 26[4], 187-194.

FL Semina, P. M. 1967. The Action of Cobalt on Chlorophyll Accumulation, the Intensity of Photosynthesis, and the Seed Crop of Buckwheat. Nauchn.Dokl.Vyssk.Shk.Biol.Nauki 3, 80-83.

FL Semina, P. M. 1970. Effect of Cobalt on the Water Regime of Buckwheat. Biol.Nauki No.6 , 69-72.

Media Shaukat-Ahmed. and Evans, H. J. 1961. The Essentiality of Cobalt for Soybean Plants Grown Under Symbiotic Conditions. Proc.Natl.Acad.Sci. 47, 24-36.

OM Sheppard, M. I. and Sheppard, S. C. 1985. Concentrations and Concentrations Ratios of U, As and Co in Scots Pine Grown in a Waste-Site Soil and an Experimentally Contaminated Soil 47149. Water Air Soil Pollut 26[1], 85-94.

OM, pH Sheppard, M. I., Thibault, D. H., and Sheppard, S. C. 1985. Concentrations and Concentration Ratios of U,As and Co in Scots Pine Grown in a Waste-Site Soil and an Experimentally Contaminated Soil 47150. Water Air Soil Pollut 26[1], 85-94.

Mix Shinonaga, Taeko and Ambe, Shizuko. 1998. Multitracer study on absorption of radionuclides in atmosphere-plant model system. Water Air and Soil Pollution 10[1-4], 93-103.

FL Shklyaev, Y. N. 1978. Effect of Top Dressing with Cobalt-60 and Carbon-14 Distribution in Vetch Plants (Vliyanie Nekornevoi Podkormki Kobal'tom na Raspredelenie 60co i 14C v Rasteniyakh Viki). Agrokhimiya 1, 115-118.

In Vit Siegel, S. M. 1977. The Cytotoxic Response of Nicotiana Protoplast to Metal Ions: A Survey of the Chemical Elements. Water Air Soil Pollut 8[1-4], 293-304.

Singh, R. K., Shukla, R. P., and Dwivedi, R. S. 1992. Effect of Cadmium, Cobalt and Nickel Salts on the Survivability of Sclerotia and Plant Infection by Sclerotium rolfsii Causing Root-Rot Disease of Barley. *Trop. Sci*. 32[3]: 269-274.

Rev Suttle, N. F. 1988. The Role of Comparative Pathology in the Study of Copper and Cobalt Deficiencies in Ruminants. J Comp Pathol 99, 241-258.

FL Tanaka, A., Tadano, T., and Ebine, Y. 1978. Comparison of Adaptability to Heavy Metals Among Crop Plants. III. Adaptability to Nickel and Cobalt. Nippon Dojo Hiryogaku Zasshi 49[4], 314-320.

Media Tiffin, L. O. 1967. Translation of Manganese, Iron, Cobalt and Zinc in Tomato. Plant Physiol. 42, 1427-1432.

Mix Tolle, Duane A., Arthur, Mickey F., Chesson, Jean, and Van Voris, Peter. 1985. Comparison of pots versus microcosms for predicting agroecosystem effects due to waste amendment. Environ.Toxicol.Chem. 4[4], 501-509.

FL Torshin, S. P., Yagodin, B. A., Klinskii, G. D., Goncharuk, E. A., Kalashnikova, E. A., and Udel'nova, T. M. 1997. Effects of selenium and cobalt on chemical composition, seed germination and formation of seedlings in lettuce. Agrokhimiya [1], 36-42.

Media Tso, T. C., Sorokin, T. P., and Engelhaupt, M. E. 1973. Effects of Some Rare Elements on Nicotine Content of the Tobacco Plant. Plant Physiol 51, 805-806.

FL Uesaka, S., Takahashi, H., and Chang, T. Y. 1953. Importance of Trace Elements in Farm Animal Feeding. II. Effect of Addition of Iron, Cobalt, and Fluorine on Propagation of Antinomycetes. Bull.Res.Inst.Food Sci., Kyoto Univ. 12, 15-23.

Rev Vanselow, A. P. 1966. Cobalt. In: H.D.Chapman (Ed.), Diagnostic Criteria for Plants and Soils, University of California, Berkeley, CA , 142, 153-142, 156.

Media Veltrup, W. 1979. The Effect of Ni2+, Cd2+, and Co2+ on the Uptake of Copper by Intact Barley Roots. Z.Pflanzenphysiol. 93, 1-9.

Media Venkatarayappa, T., Tsujita, M. J., and Murr, D. P. 1980. Influence of Cobaltous Ion (Co2+) on the Postharvest Behavior of 'Samantha' Roses. J.Am.Soc.Hortic.Sci. 105[2], 148-151.

Media Venkateswerlu, G. and Sastry, K. S. 1973. Interrelationships in Trace-Element Metabolism in Metal Toxicities in a Cobalt-Resistant Strain of Neurospora crassa. Biochem.J. 132[4], 673-680.

Media Vergnano, O. and Hunter, J. G. 1952. Nickel and Cobalt Toxicities in Oat Plants 20391.Ann.Bot.(London) 17[66], 317-328.

OM Vernano, O. and Hunter, J. G. 1952. Nickel and Cobalt Toxicities in Oat Plants. Ann.Bot. 17, 317-328.

FL Volkorezov, V. I. 1968. Pretreatment of Pinus sylvestris with Cobalt Sulfate 38625. Uch.Zap.Gor'k Univ. 90, 114-117.

Media 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.

FL Von Scharrer, K. and Schropp, W. 1933. Sand and Water Culture Experiments with Nickel and Cobalt (Sand- und Wasserkulturversuche mit Nickel und Kobalt) 20392. Z.Pflanzenernaehr.Dung.Bodenkd. 31A, 94-113 (GER).

OM Wallace, A. and Mueller, R. T. 1973. Effects of Chelated and Nonchelated Cobalt and Copper on Yields and Microelement Composition of Bush Beans Grown on Calcareous Soil in a Glasshouse 38352. Soil Sci.Soc.Am.Proc. 37, 907-908.

No Dose Wallace, A., Mueller, R. T., and Alexander, C. V. 1976. High Levels of Four Heavy Metals on the Iron Status of Plants. Comm.Soil Sci.Plant Anal. 7[1], 43-46.

Media Wallace, A., Alexander, G. V., and Chaudhry, F. M. 1977. Phytotoxicity of Cobalt Vanadium Titanium Silver and Chromium. Comm.Soil Sci.Plant Anal. 8[9], 751-756.

Media Wallace, A., Alexander, G. V., and Chaudry, F. M. 1977. Phytotoxicity of Cobalt, Vanadium, Titanium, Silver, and Chromium. Commun.Soil Sci.Plant Anal. 8[9], 751-756.

Meth Wallace, A., Romney, E. M., and Patel, P. M. 1978. Role of Synthetic Chelating Agents in Trace Metal Uptake by Plants. In: D.C.Adriano and I.L.Brisbin,Jr.(Eds.), Environmental Cemistry and Cycling Processes, Proc.Symp.Held at Augusta, Georgia, April 18-May 1, 1976, Tech.Info.Center, U.S.Dep of Energy (U.S.NTIS CONF-760429) , 645-657.

No Dose Wallace, A. 1989. Phytotoxicity of Cobalt when Uniformly Mixed in Soil Versus Localized Spot Placement in Soil. Soil Sci. 147[6], 449-450.

Media Wettlaufer, S. H., Osmeloski, J., and Weinstein, L. H. 1991. Response of polyamines to heavy metal stress in oat seedlings. Environ Toxicol Chem 10[8], 1083-1088.

Mix Wild, S. R. and Jones, K. C. 1992. Organic Chemicals in the Environment. Polynuclear Aromatic Hydrocarbon Uptake by Carrots Grown in Sludge-Amended Soil. J Environ Qual 21, 217-225.

Mix Wilson, D. O. and Reisenauer, H. M. 1970. Effects of Some Heavy Metals on the Cobalt Nutrition of Rhizobium meliloti. Plant Soil 32, 81-89.

Media Wilson, S. B. and Reisenauer, H. M. 1963. Cobalt Requirements of Symbiotically Grown Alfalfa. Plant Soil 19[3], 364-373.

OM, pH Wilson, S. B. and Hallsworth, E. G. 1965. Studies ont he Nutrition of Forage Legumes. IV. The Effect of Cobalt on the Growth of Nodulated and Non-Nodulated Trifolium subterraneum. Plant Soil 22[2], 260-279.

Media Wilson, S. B. and Nicholas, D. J. D. 1967. A Cobalt requirement for Non-Nodulated Legjmes and for Wheat. Phytochemistry 6, 1057-1066.

FL Wojciechowska, B. and Kocik, H. 1987. Effect of Cadmium, Cobalt and Bismuth Nitrate on the Root Meristem of Vicia faba L. (Wplyw Azotanow Kobaltu, Kadmu i Bizmutu na Merystem Korzeniowy Vicia faba L.). Pr.Nauk.Univ.Slask.Katowicak. 7[24], 74-91.

FL Yagodin, B. A. and Zhiznevskaya, G. Y. 1969. Variations in Protein Composition of Vicia faba Leaves During Chlorosis Induced by Excessive Cobalt 37858. Fiziol.Rast. 16[3], 505-511 (RUS)

FL Yagodin, B. A., Ovcharenko, G. A., Vasil'eva, V. Y., and Ivanova, M. A. 1970. Effect of Cobalt on Nitrate Reductase Activity in Legumes. S-kh.Biol. 5[1], 134-136.

FL Yagodin, B. A. and Sablina, S. M. 1981. Effect of Cobalt on Buckwheat Yield and on the Content of Mineral Elements and Rutin. Izv.Timiryazev.S-Kh.Akad. 6, 68-72.

FL Yagodin, B. A. and Romanova, L. P. 1982. Yield and Quality of Chinese Cabbage is Seed Treatment with Trace Elements. Izv.Timiryazev.S-Kh.Akad. 2, 98-104.

7.4 References Used for Derivation of Wildlife TRVs

Anderson, M. B., Lepak, K., Farinas, V., and George, W. J. 1993. Protective action of zinc against cobalt-induced testicular damage inthe mouse. *Reprod. Toxicol*. 7(1): 49-54. Ref #139

Anderson, M. B., Pedigo, N. G., Katz, R. P., and George, W. J. 1992. Histopathology of testes from mice chronically treated with cobalt. *Reprod. Toxicol*. 6(1): 41-50. Ref #120

Berg, L. R. and Martinson, R. D. 1972. Effect of diet composition of the toxicity of zinc for the chick. *Poultry Sci*. 51(5):1690-4. Ref #93

Bourg, W. J., Nation, J. R., and Clark, D. E. 1985. The effects of chronic cobalt exposure on passive-avoidance performance in the adult rat. *Bull. Psychon. Soc.* 3(6): 527-530. Ref #111

Brown, D. R. and L. Southern. 1985. Effect of *Eimeria acervulina* infection in chicks fed excess dietary cobalt and/or manganese. 115(3): 347-51. Ref #6215

Chetty, K. N., Subba, R. A. O. D SV, Drummond, L., and Desaiah, D. 1979. Cobalt-induced changes in immune response and atpase activities in rats. *J Environ. Sci. Health Part B Pestic. Food. Contam. Agric. Wastes*. 14(5): 525-544. Ref # 116

Corrier, D. E., Mollenhauer, H. H., Clark, D. E., Hare, M. F., and Elissalde, M. H. 1985. Testicular degeneration and necrosis induced by dietary cobalt. *Vet Pathol*. 22(6): 610-6. Ref #123

Derr, R. F., Aaker, H., Alexander, C. S., and Nagasawa, H. T. 1970. Synergism between cobalt and ethanol on rat growth rate. *J. Nutr.* 100(5): 521-524. Ref #129

Diaz, G. J., Julian, R. J., and Squires, E. J. 1994. Cobalt-induced polycythaemia causing right ventricular hypertrophy and ascites in meat-type chickens. *Avian Pathology*. 91-104. Ref #100

Diaz, G. J., Julian, R. J., and Squires, E. J. 1994. Lesions in broiler chickens following experimental intoxication with cobalt. *Avian Dis.* 38(2):308-16. Ref # 90

Domingo, J. L., Paternain, J. L., Llobet, J. M., and Corbella, J. 1985. Effects of cobalt on postnatal development and late gestation in rats upon oral administration. *Rev Esp Fisiol*. 41(3): 293-8. Ref #124

Gershbein, L. L., Gershbein, J. D., and French, R. 1983. Behavior of male rats fed low levels of metallic salts. *Res Commun Chem Pathol Pharmacol*. 39(3):507-510. Ref #136

Haga, Y., Clyne, N., Hatroi, N., Hoffman-Bang, C., Pehrsson, S. K., and Ryden, L. 1996. Impaired *myocardial function following chronic cobalt exposure in an isolated rat heart model. Trace Elements and*

Electrolytes. 13(2): 69-74. Ref # 105

Hill, C. H. 1979. The effect of dietary protein levels on mineral toxicity in chicks. *J Nutr.* 109(3): 501-7. Ref # 397

Hill, C. H. 1979. Studies on the ameliorating effect of ascorbic acid on mineral toxicities in the chick. *J. Nutr.* 109(1): 84-90. Ref # 1370

Hill, C. H. 1974. Influence of high levels of minerals on the susceptibility of chicks to Salmonella gallinarum. *J. Nutr*. 104(10):1221-1226. Ref #92

Huck, D. W. and Clawson, A. J. 1976. Excess dietary cobalt in pigs. *J Anim Sci.* 43(6): 1231-1246. Ref #86

Kadiiska, M. , T. Stoytchev, and E. Serbinova. 1985. On the mechanism of the enzyme-inducing action of some heavy metal salts. *Archives of Toxicology*. 56(3): 167-9. Ref #19290

Ling, J. R. and R. M. Leach. Jr. 1979. Studies on nickel metabolism: interaction with other mineral elements *Poult. Sci.* 58(3): 591-6 .

Maro, J. K., Kategile, J. A., and Hvidsten, H. 1980. Studies on copper and cobalt in dairy calves. *British Journal of Nutrition.* 44(1): 25-31. Ref #171

Mohiuddin, S. M., Taskar, P. K., Rheault, M., Roy, P. E., Chenard, J., and Morin, Y. 1970. Experimental cobalt cardiomyopathy. *Am Heart J.* 80(4): 532-543. Ref #132

Mollenhauer, H. H., Corrier, D. E., Clark, D. E., Hare, M. F., and Elissalde, M. H. 1985. Effects of dietary cobalt on testicular structure *Virchow Arch [Cell Pathol].* 49(3): 241-248. Ref # 119

Nation, J. R., Bourgeois, A. E., Clark, D. E., and Hare, M. F. 1983. The effects of chronic cobalt exposure on behavior and metallothionein levels in the adult rat. *Neurobehav Toxicol Teratol*. 5(1): 9-15. Ref #126

Paternain, J. L., Domingo, J. L., and Corbella, J. 1988. Developmental toxicity of cobalt in the rat. *J. Toxicol. Environm. Health*. 24(2):193-200. Ref #109

Paulov, S. 1971. Changes of growth and of serum proteins in ducklings intoxicated with cobalt. *Nutr Metab* 13(1):66-70. Ref #91

Paulov, S., Veselovsky, J., and Demers, J. M. 1971. Metabolic pool of heart proteins and amino acids in cobalt-poisoned ducklings. *Acta Physiol Acad Sci Hung* . 40(2): 173-177. Ref #84

Pedigo, N. G. and Vernon, M. W. 1993. Embryonic losses after 10-week administration of cobalt to male mice. *Reprod. Toxicol.* 7: 111-116. Ref #187

Pedigo, N. G., George, W. J., and Anderson, M. B. 1988. Effects of acute and chronic exposure to cobalt on male reproduction in mice. *Reprod Toxicol* . 2(1): 45-53. Ref # 121

Seidenberg, J. M., Anderson, D. G., and Becker, R. A. 1986. Validation of an in vivo developmental toxicity screen in the mouse. *Teratog Carcinog Mutagen.* 6:361-374. Ref #113

Southern, L. L. and Baker, D. H. 1981. The effect of methionine or cysteine on cobalt toxicity in the chick. *Poultry Sci*. 60(6): 1303-8. Ref #81

Van Vleet, J. F., Boon, G. D., and Ferrans, V. J. 1981. Induction of lesions of selenium-vitamin E deficiency in ducklings fed silver, copper, cobalt, tellurium, cadmium, or zinc: protection by selenium or vitamin E supplements. *Am J Vet Res* 42(7): 1206-1217. Ref #80

Van Vleet, J. F., Boon, G. D., and Ferrans, V. J. 1981. Induction of lesions of selenium-vitamin E deficiency in weanling swine fed silver, cobalt, tellurium, zinc, cadmium, and vanadium. Am. J. Vet. Res. 42(5): 789-799. Ref #149

7.5 References Rejected for Use in Derivation of Wildlife TRVs

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.

Abstract 1973. annual report of the secretary for agricultural technical services forthe period 1 july 1971 to 30 june 1972. *Department of Agricultural Technical Services, South Africa* : 270pp.

Nut def 1985. *Annual Report of the West of Scotland Agricultural College* : 92-95.

Unrel Birds and fowls fodder additive prescription and its prepn. *Faming Zhuanli Shenqing Gongkai Shuomingshu* : 10 pp.

Diss Content and evolution of cadmium, cobalt, chromium, copper, nickel, lead, and zinc in soils of l'horta and ribera baixa regions (valencia) (spain)

Nut def 1978. grasslands and animal health. nutritional disorders in cattle andsheep. *Annotated Bibliography, Commonwealth Bureau of Animal Health* (No.V22)

Unrel Metallic complexes of streptogramin-b, their preparation and their use in animal food. *Eur. Pat. Appl.* 12 pp.

HHE 1971. Synergism of cobalt and ethanol. *Nutr Rev* 29(2): 43-5.

FL Abe, H., Urakabe, S., Sugita, M., Shichiri, M., and Suematsu, T. 1973. environmental pollution and health problems: pathophysiology: interpretation of physical disorders induced by heavy metals. *Jap. J. Clin. Med.* 31(6): 2017-2026.

FL Admina, L. 1983. trace element requirements of young pigs. *Svinovodstvo.*(4): 28-29.

Unrel Agarwala, O. N., Mehra, U. R., and Pachauri, V. C. 1985. plasma cholesterol and yellowing of wool in chokla sheep. *Indian Vet J.* 62(2): 182-183.

FL Akulov, A. V. and Shumilov, K. V. 1967. [the effect of trace elements on the development of immunomorphological reactions in guinea pigs in brucellosis]. *Veterinariia.* 44(3): 38-40.

FL Aleksiev, A., Danov, D., and Semkov, M. 1972. effect of differentiated feeding on the sperm of cocks and the incubation characteristics of the eggs. 2. effect of differentiated feeds with a large increase in protein and cobalt. *Veterinarnomeditsinki Nauki.* 9(8): 81-88.

FL Aleksiev, A. D., Kr"steva, E., and Aleksieva-Drbokhlavova, D. 1986. study on the interaction of vitamin a and cobalt in feeding broilerchickens. *Zhivotnov"Dni Nauki* 23(6): 84-89.

FL Aleksiev, A. D., Kr"Steva, E., and Aleksieva-Drboklavova, D. a study on interaction of vitamin a with cobalt on feeding broiler chickens. *Zhivotnov'Dni Nauki. 23 (6). 1986. 84-89.*

Mix Aleksiev, A. D., Krusteva, E., and Aleksieva-Drbokhlavova, D. 1986. interaction of vitamin a with cobalt on feeding broiler chickens. *Zhivotnovud. Nauki.* 23(6): 84-9.

CP Allen, W. M. 1984. use and misuse of minerals and trace elements in cattle diets. *British Cattle Veterinary Association Proceedings for 1983-1984.* 47-52.

Surv Amiard-Triquet, C., Pain, D., and Delves, H. T. exposure to trace elements of flamingos living in a biosphere reserve, the camargue (france). *Environ. Pollut. (1991)* 69(2-3): 193-201 .

Unrel Ammerman, C. B. 1970. recent developments in cobalt and copper in ruminant nutrition a review. *J Dairy Sci.* 53(8): 1097-1107.

CP Ammerman, C. B., Henry, P. R., Black, J. R., Margolin, J. E., Echevarria, M. G., and Miles, R. D. 1985. tissue uptake of trace minerals as a measure of their bioavailability in ruminants and poultry. *Trace Elem. Man Anim. -- TEMA 5 Proc. Int. Symp., 5th* : Meeting Date 1984, 699-702. Editor(s): Mills, C. F.; Bremner, I.; Chesters, J. K. Publisher: CAB, Farnham Royal, Slough, UK.

Rev Ammerman, C. B. and Miller, S. M. 1972. biological availability of minor mineral ions: a review. *J. Anim. Sci.* 35(3): 681-694.

Mix Amrith Kumar, M. N., Bhaskar, B. V., Nagarcenkar, R., and Sampath, S. R. 1973. Study on the effect of supplementation of copper, cobalt and liv-52 in the ration of heifers. *Indian Journal of Nutrition and Dietetics.* 10(3): 139-147.

Surv Anderson, S. H., Dodson, C. J., and Van, Hook R. I. 1976. Comparative retention of 60co, 109cd and 137cs following acute and. *Erda/Radiological Soc of Am 4th Natl Symp on Radioecology, Ore.*: p321(4).

Surv Andreu Perez, Vicente. 1991. Content and evolution of cadmium, cobalt, chromium, copper, nickel, lead, and zinc in soils of l'horta and ribera baixa regions (valencia) (spain): <original> contenido y evolucion de cadmio, cobalto, cromo, cobre, niquel, plomo, cinc en suelos de las comarcas de l'horta y la ribera baixa (valencia).

Acute Andrews, E. D. 1965. Cobalt poisoning in sheep. *NZ Vet. J.* 13: 101.

CP Apsite, M. 99-124. Editor(s): Bermane, S.. Publisher: Izd. "Zinatne", Riga, USSR.

FL Apsite, M. 1968. 63-83. Editor(s): Bermane, S.. Publisher: Izd. "Zinatne", Riga, USSR.

Mix Apsite, M. Effect of trace nutrients and amino acid mixture on the blood system of chicks. *Regul. Rosta Metab. Zhivotn. (1971)* 169-79. Editor: 169-79. Editor(s): Valdmanis, A. Publisher: "Zinatne", Riga, Latv. SSR.

Phys Arvy, L. 1970. The kidney and cobamides. *Laval Med.* 41(3): 393-428.

In Vit Asatryan, R. M., Badalyan, R. B., and Simonyan, A. A. anion-sensitive atpase in the subcellular fractions of hen brain in ontogenesis. *Neirokhimiya (1986)* 5(2): 194-9 .

FL Aslanyan, M. M. and Dariush, N. S. 1972. stimulation of reproduction in rams by trace elements. *Ovtsevodstvo.*(9): 38-39.

Phys Assan, R., Pignard, P., Rosselin, G., and Tchobroutsky, G. 1968. [glucagon: recent physiological data]: <original> le glucagon. donnees physiologiques recentes. *Pathol Biol.* 16(21): 979-1002.

Mix Atabekov, T. A., Rakhimov, T. T., Smaglyuk, N., Salikhodzhaev, Z., Seifullin, F. Kh., and Iskhanbekov, B. I. 1985. effect of covit on biochemical indexes of (various) organs in poultry. *Uzb. Biol. Zh., N4, P55-7.*

Rev ATSDR. 1990. Toxicological Profile for Cobalt.

FL Babin, Ya. A., Latyshev, V. I., Strugovshchikov, V. R., Ogarenko, N. B., Kolganov, V. A., Kolpakova, L. V., Vasyunin, V. V., and Kolesnikov, S. A. 1985. effect of trace elements on egg laying and the nutritional value of hen eggs. *Khim. Sel'Sk. Khoz.*(5): 36-7.

Mix Babin, Ya. A., Latyshev, V. I., and Vasyunin, V. V. 1982. use of paired trace element salt combinations in chick rations. *Khim. Sel'Sk. Khoz.* 2: 44-7.

FL Babin, Ya. A., Vasyunin, V. V., and Latyshev, V. I. 1975. effect of cobalt, iodine, and zinc salts on oxidative phosphorylation in chick tissues. *Biol. Akt. Veshchestva (Mikroelem. Vitam. Drugie) Rastenievod., Zhivotnovod. Med.* 45-8. Editor(s): Babin, Ya. A. Publisher: Sarat. S-kh. Inst., Saratov, USSR..

FL Baiturin, M. A. and Tanatarov, A. B. determination of effective doses of the trace elements cobalt and manganese during the raising of chicks. *Tr. Alma-At. Zoovet. Inst. (1968).* 15(3): 87-90 CODEN: TAZIAK.

FL Baiturin, M. A. and Tanatarov, A. B. 1972. determination of optimum doses of a combination of trace elements for ducklings. *Tr. Alma-At. Zoovet. Inst.* 24: 135-8.

FL Baiturin, M. A. and Tanatarov, A. B. 1972. effect of iodine and cobalt on growth and development of chicks. *Tr. Alma-At. Zoovet. Inst.* 24: 116-20.

FL Baiturin, M. A. and Tanatarov, A. B. 1968. effect of the trace elements cobalt and manganese on the growth and development of chicks. *Tr. Alma-At. Zoovet. Inst.* 15(3): 91-3.

Rev Baker, D. H. and Czarnecki-Maulden, G. L. 1987. pharmacologic role of cysteine in ameliorating or exacerbating mineraltoxicities. *Journal of Nutrition* 117(6): 1003-1010.

Drug Bal, M. S. and Dwarkanath, P. K. 1989. effect of cobalt feeding on the blood and milk vitamin b-12 levels in cattle. *Indian Vet J.* 66(4): 300-302.

FL Balakhontseva, V., Dubinskaya, A., and Rozhkova, M. 1986. products of microbiological synthesis - paprin. *Mukomol'No-Elevatornaya i Kombikormovaya Promyshlennost'* (10): 41-42.

HHE Balazs, T. and Herman, E. H. 1976. toxic cardiomyopathies. *Ann Clin Lab Sci.* 6(6): 467-76 .

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

Nut def Barnouin, J., Quechon, M., Petit, B., Nicolas, J. A., and Brochart, M. 1985. continuous eco-pathological survey. 5. the main diseases and healthmanagement of sheep flocks under semi-confinement conditions. *Bulletin Technique Centre De Recherches Zootechniques Et Veterinaires De Theix.*(No.61): 11-19.

Mix Bastien, R. W., Bradley, J. W., Pennington, B. L., and Ferguson, T. M. 1979. effect of dietary mineral supplements on radius breaking strength andegg characteristics of caged layers. *Poultry Science* 58(1): 90-92.

Drug Beers, K. W., Nicoll, D. W., Anestis, D. K., Brown, P. I., and Rankin, G. O. 1993. effect of microsomal enzyme modulators on n-(3,5-dichlorophenyl)-2-hydroxysuccinimide (ndhs)-induced nephrotoxicity in the fischer 344 Rat. *Toxicology.* 84(1-3): 141-155.

Phys Behlke, J., Krantz, S., Lober, M., and Fiedler, H. 1969. [hydrodynamic behavior of fibrinogen from cobalttreated rabbits]: <original> zum hydrodymanischen verhalten des fibrinogens kobaltbehandelter kaninchen. *Acta Biol Med Ger .* 23(6): 933-6.

Nut Beker, V. F., Urtane, M. S., Vasil'eva, S. V., Krauze, R. Yu., Apsite, M. R., and Kalntsiema, V. Kh. 1984. composition and biological value of biomass from mycelium of the funguspolyporus squamosus a-42. <. *Document Title>Transportnye i Obmennye Protsessy v Kishechnikezhivotnykh.* 183-194.

Bio Acc Belokobyl'skii, A. I., Ginturi, E. N. , Shoniya, N. I., Rcheulishvili, A. N., and Mosulishvili, L. M. 1990. trace elements in chromatin in embryo- and postembryogenesis. *Soobshch. Akad. Nauk Gruz. SSR (1990)* 137(1): 157-60 .

Unrel Belokobyl'skii, A. I., Ginturi, E. N., Shoniya, N. I., Rcheulishvili, A. N., and Mosulishvili, L. M. 1990. trace elements in chromatin in embryogenesis and postembryogenesis. *Soobshch Akad Nauk Gruz Ssr.* 137(1): 157-160.

Bio Acc Belokobyliskii, A. I., Ginturi, E. N. , Saginadze, N. V., and Shoniya, N. I. 1983. change of iron, zinc, rubidium, selenium and cobalt content in chick embryos in the course of their development. *Soobshch. Akad. Nauk Gruz. SSR* 109(1): 149-51 .

Bio Acc Bendell-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.

Mix Bengoumi, M., Essamadi, A. K., Tressol, J. C., Chacornac, J. P., and Faye, B. a. 1998. comparative effects of selenium supplementation on the plasma selenium concentration and erythrocyte glutathione peroxidase activity in cattle and camels. *Animal Science .* 67(3): 461-466.

Mix Bengoumi, M., Essamadi, A. K., Tressol, J. C., and Faye, B. a. 1998. comparative study of copper and zinc metabolism in cattle and camel. *Biological Trace Element Research.* 63(2): 81-94.

FL Berestova, V. I. 1981. cobalt content in the bodies on mink, arctic foxes (alopex lagopus) and silver foxes at various stages of growth: <original> soderzhanije kobal'ta v organizme norok, nestsov i lisits ranogo vozrasta. *Scientifur.* 5(1): 34-37.

Phys Berlin, Nathaniel. 1949.*Studies on the Mechanism and Development of the Cobalt Polycythemia in the Rat With the Aid of Radioactive Isotopes*

Bio Acc Besschetnov, I. I. and Chorayan, O. G. dynamics of informational characteristics of the chemical content of developing chicken embryo organs. *Arkh. Anat.* Gistol. Embriol. (1981): 81(11), 89-92 .

FL Bessonov, A. I., Grozhevskaya, S. B., Vikharev, V. Ya., and Savkin, V. V. 1986. sperm yield and non-specific reactivity in boars given a diet containing iodine and cobalt.: <document title>puti povysheniya produktivnosti svinei i ovets. 79-85.

Unrel Bicanin, M. 1975. contribution to the knowledge of quality of grassland herbage on thewestern sides of mount sara with special reference to essential traceelements in the diet of sheep.

Veterinaria, Yugoslavia. 24(2): 199-207.

Phys Binnerts, W. T., D. Giesecke, G. Dirksen editor, and M. Stangassinger (editor). 1981. intensification and trace element intake of dairy cows. *Metabolic Disorders in Farm Animals. Proceedings of the IVth International Conference on Production Disease in Farm Animals.*: 263-266.

Nut def Black, H., Hutton, J. B., Sutherland, R. J., and James, M. P. 1988. white liver disease in goats. *New Zealand Veterinary Journal.* 36(1): 15-17.

Diss Blalock, T. L. 1986. studies on the role of iron in the reversal of zinc, cadmium, vanadium, nickel and cobalt toxicities in broiler pullets. *Diss. Abstr. Int. B 1986, 47(2), 577-8.*: 188 pp.

CP BLALOCK, T. L. and HILL, C. H. 1986. Mechanisms of alleviation of zinc cadmium vanadium nickel and cobalt toxicities by dietary iron. *70th Annual Meeting of the Federation of American Societies for Experimental Biology*

Bio Acc Blomqvist, Sven, Frank, Adrian, and Petersson, Lars R. 1987. Metals in liver and kidney tissues of autumn-migrating dunlin calidris alpina and curlew sandpiper calidris ferruginea staging at the baltic sea. *Mar. Ecol Prog. Ser. (1987)* 35(1-2): 1-13 .

Phys Boitor, I., Muntean, M., Groza, I., Moise, D., Musca, M., Kadar, L., and Ghitulescu, C. 1988. Investigations on the stimulating effect of minerals in heifers with acquired utero-ovarian hypoplasia: <original> cercetari privind efectul stimulativ al unui complex mineral asupra unui lot de tineret bovin cu hipoplazie utero-ovariana dobindita. *Buletinul Institutului Agronomic Cluj-Napoca: Seria Zootehnie Si Medicina Veterinara* 42: 91-94.

FL Bolotnikov, I. A., Malazhaev, E. D., Nikol'skii, V. M., and Smirnova, T. I. 1988. Use of complex of trace elements and iminodisuccinic acid in poultryhusbandry. *<Document Title>3 Vsesoyuznoe Soveshchenie Po Khimii i Primeneniyukompleksonov i Kompleksonatov Metodov. Tezisy Dokladov.* 258-259.

FL Bonnet-Masimbert, O., Prenat, M. F., Valentin, J., and Sengel, P. 1971. [Restatement of a method of analysis by activation, using the (p, 2n) reaction followed by spectrometry applied to iron determination in chicken blastoderm]. <original> mise au point d'une methode d'analyse par acivation, utilisant la reaction (p,2n) suivie de spectrometri , appliquee au dosage du fer dans le balstoderme de poulet. *Comptes Rendus Hebdomadaires Des Seances De L'Academie Des Sciences.*

FL Bonomi, A., Quarantelli, A., Sabbioni, A., Superchi, P., and Lucchelli, L. 1985. Chelated trace element complexes in the feeding of ducks. (experimentalcontribution). *Annali Della Facolta Di Medicina Veterinaria, Universita Di Parma* 5: 153-166.

FL Bonomi, A., Quarantelli, A., Superchi, P., Sabbioni, A., and Bolsi, D. 1982. Chelated trace element complexes in the feeding of meat turkeys. *Annali Della Facolta Di Medicina Veterinaria Di Parma* 2: 103-125.

Mix Bonomi, A., Quarantelli, A., Superchi, P., Sabbiono, A., Lucchelli, L., and Ashmead, H. D. 1993.*The Dynamics of Feeding Amino Acid Chelates to Broilers.: The Roles of Amino Acid Chelates in Animal Nutrition* : 302-317.

Nutrition Bonomi, Alberto, Quarantelli, Afro, Superchi, Paola, Sabbiono, Alberto, and Lucchelli, Luigina. 1993. The dynamics of feeding amino acid chelates to broilers. *Roles Amino Acid Chelates Anim. Nutr. (1993)* 302-17. Editor: 302-17. Editor(s): Ashmead, H. DeWayne. Publisher:

Noyes, Park Ridge, N. J..

FL Boquist, L., Falkmer, S., Havu, N., and Pihl, E. 1968. [Insulin biosynthesis, storage and secretion. 8. pancreatic-islet tissue and heavy metals--some ultrastructural and experimental observations]: <original> insulinets syntes, upplagring och sekretion. 8. pankreasovavnad och tunga metaller--n.ang.agra ultrastrukturella och experimentella iakttagelser. *Lakartidningen.* 65(37): 3603-7.

Unrel Bowell, R. J(A) and Ansah, R. K. 1993. Trace element budget in an african savannah ecosystem. *Biogeochemistry (Dordrecht)* 20(2): 103-126.

Unrel Bramson, P. E. and Corley, J. P. 1972. *Environmental Status of the Hanford Reservation for 1971*

Alt Bruere, A. N. 1977. Poor reproductive performance in sheep: the effects of low bodyweight(a case study) (cobalt deficiency and parasitism). *Proceedings of the 7th Seminar of the Nw Zealand Veterinary Association Sheep Society, 1977* : 22-29.

Surv Burch, R. E., Williams, R. V., and Sullivan, J. F. 1973. Effect of cobalt, beer, and thiamin-deficient diets in pigs. *American Journal of Clinical Nutrition.* 26(4): 403-408.

Surv Burger, J. and Gochfeld, M. 1988-1989. Metals in tern eggs in a new jersey estuary usa a decade of change. *Environ Monit Assess.* 11(2): 127-136.

No Oral Cain, Stephen M. 1975. Oxygen delivery and utilization in dogs with a sublethal dose of cobalt chloride. *J Appl Physiol.* 38(1): 20-25.

Unrel Calvet, H., Friot, D., and Chambon, J. 1972. Effect of mineral supplements on growth and on some biochemicalindicators of mineral metabolism in tropical cattle. *Revue D'Elevage Et De Medecine Veterinaire Des Pays Tropicaux .* 25(3): 397-408.

FL 1997. Effects of chelated trace-elements with aminoacids on egg shell quality in commercial laying hens. <Original> Effetto degli oligoelementi chelati con aminoacidi sulla qualita' del guscio nella gallina ovaiola :

Mix Cavalheiro, A. C. L., Trindade, D. S., Rodrigues, C. O., Costanzi, A. R., Castagna, M., and Arnt, L. M. 1989. The effects of mineral supplementation for growth of grazing lambs. *Rev Soc Bras Zootec: Revista Da Sociedade Brasileira De Zootecnia.* 18(2): 164-171.

FL Chaika, P. A. 1968. [Effect of cobalt and copper salts on the toxic action of lead on the animal organism]: <original> o vliianii solei kobal'ta i medi pri toksicheskom vozdeistvii svintsa na organizm zhivotnykh. *Vopr Pitan.* 27(6): 29-33.

No COC Chang, D. M. a and Kim, J. K. 1982. Effects of hormone treatments on ovarian responses fertility and parturition in imported holstein of Jeju Island (Korea r.): the. *Korean Journal of Animal Sciences.* 24(5): 440-443.

FL Choi, W. J., Kang, M. H., and Chung, K. H. 1982. Studies on the influence of cobalt on chromium (iii) toxicity in the chicks. *Korean Journal of Animal Sciences.* 24(5): 440-443.

FL Choi, Won J., Kang, Myun H., and Chung, Keun H. 1981. Studies on the influences of cobalt on chromium(vi) toxicity in the chicks. *Hanguk Ch'Uksan Hakhoe Chi.* 23(6): 437-40.

Gene Chopikashvili, L. V., Bobyleva, L. A., and Zolotareva, G. N. 1989. Genotoxic effects of heavy metals and their salts in an experiment on drosophila and Mammalia. *Tsitol Genet.* 23(3): 35-38.

Mix Chumachenka, U. Ya. and Zharkina, T. A. 1983. Changes in the activity of transaminases in the liver of pigs givendiets with different vitamin and mineral mixtures. *Vestsi Akademii Nauk BSSR, Sel'Skagaspadarchykh Navuk.*(1): 108-111, 127.

FL Chung, K. H. Samyuk Junior Agricultural Coll. Seoul Korea R., Kang, M. H. Korea Univ. Seoul Korea R. Coll. of Agriculture, and Kim, C. S. Korea Advanced Inst. and Tech. Seoul Korea R. 1983. The toxicity of trivalent chromium and its interaction with cobalt and zinc in chicks. *Korean Journal of Animal Sciences.* 25(6): 686-691.

Unrel Cipagauta Hernandez, M. 1989. *[Growth of Small Cows on Indigenous Grasslands of the Eastern Plains of Colombia, With the Supplement of Three Sources of Phosphorus]*

CP Clark, R. G. 1982. Trace element analysis in the diagnosis of poor growth in sheep; withspecial reference to cobalt and selenium. *Proceedings of the 12th Seminar of the Sheep and Beef Cattle Society of the New Zealand Veterinary Association, 8th-12th November 1982.* 150-163.

Nut def Clark R G, Burbage J, Marshall P M, Valler T, and Wallace D. 1986. Absence of a vitamin b12 weight gain response in two trials with growing red deer (cervus Elaphus). *New Zealand Veterinary Journal.* 34(11): 199-201, illustr.

Model Clark, R. G., Wright, D. F., and Millar, K. R. 1985. A proposed new approach and protocol to defining mineral deficienciesusing reference curves. cobalt deficiency in young sheep is used as amodel. *New Zealand Veterinary Journal.* 33(1/2): 1-5.

Nut def Cloete, S. W. P a, Van, Niekerk F E, Kritzinger, N. M., Van, Der Merwe G D, Heine, E. W. P., and Scholtz, Anna J a. 1994. Production responses of sheep supplemented with copper, cobalt and selenium on kikuyu ryegrass pastures. *Journal of the South African Veterinary Association.* 65(2): 52-58.

Surv Cloutier, N. R., Clulow, F. V., Lim, T. P., and Dave, N. K. 1985. Metal copper nickel iron cobalt zinc lead and radium-226 levels in meadow voles microtus-pennsylvanicus living on nickel and uranium mine tailings in ontario canada environmental and tissue levels. *Environ Pollut Ser B Chem Phys.* 10(1): 19-46.

Surv Cloutier, N. R., Clulow, F. V., Lim, T. P., and Dave, N. K. 1986. Metal copper nickel iron cobalt zinc lead and radium-226 levels in tissues of meadow voles microtus-pennsylvanicus living on nickel and uranium mine tailings in ontario canada site sex age and season effects with calculation of average skeletal radiation Dose. *Environ Pollut Ser a Ecol Biol.* 41(4): 295-314.

Rev Cohen, MD, Bowser, DH, and Costa, M. 1996. Chapter 16: carcinogenicity and genotoxicity of lead, beryllium, and other metals. *Toxicology of Metals*. 253-284.

Chem Meth Comar, C. L., Davis, G. K., and Taylor, R. F. 1946. Cobalt metabolism studies: radioactive cobalt procedures with rats and cattle. *Arch Biochem.* 9: 149.

Rev Corah, L. R. and Ives, S. 1991. The effects of essential trace minerals on reproduction in beef cattle. *Veterinary Clinics of North America, Food Animal Practice.* 7(1): 41-57.

No Dose Corah, L. R. and Ives, S. 1992. Trace minerals in cow herd nutrition programs. *Agri-Practice.* 13(4): 5-7.

No Dose Corah, L. R. and Ives, S. 1992. Trace minerals in cow herd nutrition programs part 2. cobalt iodine selenium and Zinc. *Agri-Practice.* 13(4): 5-7.

No Dose Corrier, D. E., Rowe, L. D., Clark, D. E., and Hare, M. F. 1986. Tolerance and effect of chronic dietary cobalt on sheep. *Vet Hum Toxicol.* 28(3): 216-9.

Unrel Damron, B. L. and Hall, M. F. 1983. Influence of varying vitamin d3 levels upon the performance of chicks receiving citrus sludge in their diet. *Fla. Sci.* 46(2): 82-8.

Mix Danilov, V. B., Agaev, R. A., Suleimanova, E. U., and Teplova, T. I. 1987. Toxicity of tetradimethylsulfoxide hexamethylene tetramine cobalt chloride dhchco and o nitrophenol. *Gig Sanit.* 0(12): 92.

Nut def Dankowski, A. and Janicki, B. 1991. Preliminary observations on mineral and vitamin feeding of merino ewesduring breeding season. *Akademia Techniczno-Rolnicza w Bydgoszczy, Zeszyty Naukowe, Zootechnika.* 21(176): 33-41.

Plant Darmody, Robert G., Green, William P., and Dreher, Gary B. 1998. Coal slurry solids/coal fluidized bed combustion byproduct mixtures as plant growth media. *Int. J. Surf. Min.* (Reclam. Environ.): 12(3), 111-115 .

Surv Davies, G. R. and Crawshaw, R. 1978. A field study of the soil and herbage relationships for the trace elements copper, molybdenum and cobalt. *Experimental Husbandry.*(No.34): 53-60.

Mix Davies, S. C., White, C. L., and Williams, I. H. 1995. Increased tolerance to annual rye grass toxicity in sheep given a supplement of cobalt. *Australian Veterinary Journal.* 72(6): 221-224.

Rev Deas, D. W., Melrose, D. R., Reed, H. C. B., Vandeplassche, M., and Pidduck, H. 1979. Other non-infectious abnormalities. *Fertility and Infertility in Domestic Animals, 3rd Edition* : 137-159.

Rev Deas, D. W., Melrose, D. R., Reed, H. C. B., Vandeplassche, M., Pidduck, H., and <Editors> J.A. Laing. 1979. Chapter 7: other non-infectious abnormalities. *Fertility and Infertility in Domestic Animals* : 137-159.

FL Demers, J. M. and Paulov, S. 1971. [Hematopoiesis in ducklings on a high cobalt level diet]: <original> l'hematopoiese chez le caneton nourri a un regime a haute teneur en cobalt. *C R Seances Soc Biol Fil.* 165(8): 1733-6.

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 sostoianiiakh shchitovidnoi zhelezy. *Probl Endokrinol (Mosk).* 16(5): 102-6.

Bio Acc Denneman, W. D. and Douben, P. E. T. 1993. Trace metals in primary feathers of the barn owl (tyto alba guttatus) in the netherlands. *Environ. Pollut.* 82(3): 301-10 .

FL Derkach, V. V. and Burmakina, L. I. 1970. effect of cobalt on the formation of precipitins and development of the arthus phenomenon. *Zhurnal Mikrobiologii Epidemiologii i Immunobiologii.* 47(2): 59-62.

Mix Draganov, I. F., Vrakin, V. F., and Volkonskii, V. A. 1991. effect of trace element concentration in the diet on metabolism in young bulls fattened using malt residues. *Izvestiya Timiryazevskoi Sel'Skokhozyaistvennoi Akademii.* 0(3): 133-144.

Unrel Dubrovol'skii, V. V. biogeochemistry of atolls. *Tr. Biogeokhim. Lab.* Akad. Nauk SSSR (1990): 21, 5-34 .

Nut def Duncan, I. F., Greentree, P. L., and Ellis, K. J. 1986. cobalt deficiency in cattle. *AUST VET J: Australian Veterinary Journal.* 63(4): 127-128.

Nut def Duncan, W. R. H., Morrison, E. R., and Garton, G. A. 1981. effects of cobalt deficiency in pregnant and post parturient ewes and their lambs. *British Journal of Nutrition.* 46(2): 337-344.

Phys Duncan, W. R. H., OErkov, E. R., Fraser, C., and Garton, G. A. 1974. effect of processing of dietary barley and of supplementary cobalt and cyanocobalamin on the fatty acid composition of lamb triglycerides,with special reference to branched-chain components. *British Journal of Nutrition.* 32(1): 71-75.

No Oral Dunn, K. M., Ely, R. E., and Huffman, C. F. 1952. alleviation of cobalt toxicity in calves by methionine administration. *J Anim Sci.* 11: 326.

FL Dzanagov, Kh. B. 1966. effect of trace element additives in chick rations on their growth. *Uch. Zap., Kabardino-Balkar. Gos. Univ.* 28: 297-303.

No Oral Eaton, R. P. 1972. cobalt chloride-induced hyperlipemia in the rat: effects on intermediary metabolism. *Am J Physiol.* 222(6): 1550-1557.

No Oral Edel, J a, Pozzi, G., Sabbioni, E., Pietra, R., and Devos, S. 1994. metabolic and toxicological studies on cobalt. *Sci Total Environ.*: 233-244.

FL Efthymiou, M. L., Cristofini, P., Pierron, E., and Djezzar, S. 1995. diagnosis of toxic or drug induced pancreatitis. *Therapie (Paris).* 50(5): 467-468.

Nut def El-Zeini, M. 1976. growth and chemical composition of some bones and muscles of rabbits on cobalt deficient diets. *S-KH BIOL: Sel'Skokhozyaistvennaya Biologiya.* 11(5): 740-743.

FL Ermenkova, Lidiya and Ermenkov, Kiril. 1967. effect of manganese, cobalt, and iodine trace elements on immunobiological reactions in chickens. *Zhivotnovud. Nauki.* 4(7): 75-81.

Mix Eskin, G. 1984. trace elements in the diet for fattening pigs. *Svinovodstvo, Moscow.* (7): 35-36.

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. *Veterinariya (Moscow).* 9: 66-7.

Fate Fatima, I., Waheed, S., Mannan, A., and Qureshi, I. H. 1985. distribution of toxic and essential elements in various chicken organs. *Toxicol. Environ. Chem.* 10(4): 321-32.

Bio Acc Fendick, E. A., Stevens, G. L., Brown, R. J., and Jordan, W. P. 1989. element content in tissues of four rodent species sampled in the geysers geothermal steamfield california usa. *Environ Pollut.* 58(2-3): 155-178.

Nut def Ferguson, E. G. W., Mitchell, G. B. B., and MacPherson, A. Scottish Agricultural Colleges Veterinary Investigation Centre Auchincruive Ayr KA6 5AE UK. 1989. cobalt deficiency and ostertagia circumcincta infection in lambs. *Veterinary Record.* 124(1): 20.

Unrel Ferm, V. H. and Carpenter, S. J. 1968. the relationship of cadmium and zinc in experimental mammalian Teratogenesis. *Lab Invest* . 18: 429-432.

FL Fiedler, H. and Hoffmann, H. D. 1970. [the effect of nickel(ii)-l-glutamate and of various cobalt complexes on the behavior of several lipid components in rabbits]: <original> uber die wirkung von nickel(ii)-l-glutamat und verschiedenen kobaltkomplexen auf das verhalten einiger lipidkomponenten bei kaninchen. *Acta Biol Med Ger.* 25(3): 389-98.

Drug Field, A. C., Suttle, N. F., Brebner, J., and Gunn, G. W. 1988. an assessment of the efficacy and safety of selenium and cobalt included in an anthelmintic for sheep. *Veterinary Record.* 123(4): 97-100.

FL Filippov, A. 1973. growth of piglets given supplements of cobalt and iodine. *Svinovodstvo.*(No.4): 23.

FL Age dynamics of the level of some trace nutrients and nitrogenous substances in chick blood and liver Dokl. Sib. Konf., 3rd (1971) : Meeting Date 1969, 374-9. Editor(s): Filippov, V. R. Publisher: Akad. Nauk SSSR, Sib. Otd., Buryat. Filial, Ulan-Ude, USSR.

Unrel Fini, C., Palmerini, C. A., Damiani, P., Stochaj, U., Mannherz, H. G., and Floridi, A. 1990. 5'-nucleotidase from bull seminal plasma, chicken gizzard and snake venom is a zinc metalloprotein. *Biochim Biophys Acta.* 1038 (1). 18-22.

Nut def Fisher, G. and MacPherson, A. 1986. co deficiency in the pregnant ewe and lamb viability. *Proceedings, Sixth International Conference on Production Disease in Farm Animals, September 1986, Belfast, UK.*: 158-162.

Nut def Fisher, G. E. J. and Macpherson, A. 1991. effect of cobalt deficiency in the pregnant ewe on reproductive performance and lamb viability. *Res Vet Sci.* 50(3): 319-327.

Nut def Fisher, G. E. J. and MacPherson, A. 1992.*Effects of Cobalt Deficiency in the Pregnant Ewe on Neonatal Lamb Survival Occasional Publication - British Society of Animal Production.* 15: 169-171.

BioAcc Fisher, Nicholas S., Fowler, Scott W., Boisson, Florence, Carroll, JoLynn, Rissanen, Kristina, Salbu, Britt, Sazykina, Tatiana G., and Sjoeblom, Kirsti-Liisa. radionuclide bioconcentration factors and sediment partition coefficients in arctic seas subject to contamination from dumped nuclear wastes. *Environ. Sci. Technol. (1999)* 33(12): 1979-1982 .

Gene Flanagan, P. R., Haist, J., Mackenzie, I., and Valberg, L. S. 1984. intestinal absorption on zinc: competitive interactions with iron, cobalt, and copper in mice with sex-linked anemia (sla). *Canadian Journal of Physiology and Pharmacology* 62(9): 1124-1128.

FL Freitas, E. A. G. de, Cordeiro, J. L. F., and Torres, C. L. A. 1995. importance of minerals for the reproductive performance of beef cattle. *Agropecuaria Catarinense.* 8(2): 47-50.

Unrel Gaffarov, A. K. 1981. trace nutrients in tadzhikistan animal husbandry. *Mikroelem. SSSR.* 22: 43-8.

FL Gaffarov, A. K. and Kamalov, A. 1974. effect of copper manganese and cobalt salts on growth development and change of the thyroid of gissar ram lambs. *Izvestiya Akademii Nauk Tadzhikskoi Ssr Otdelenie Biologicheskikh Nauk.* 3: 85-88.

FL Gaffarov, A. K. and Saidov, N. 1975. trace elements in ewe rations. *Trudy, Tadzhikskii Sel'Skokhozyaistvennyi Institut.* 21: 16-20.

Acu Gainer, J. H. 1977. effects of interferon of heavy metal excess and zinc deficiency. *Am J Vet Res.* 38(6): 863-867.

Drug Gainer, J. H. 1973. effects of metals on viral infections in Mice. *Environ Health Perspect.* 4:

98-99.

No Oral Garban, Z., Voiculescu, L., Checiu, M., and Eremia, J. 1984. the influence of zinc and cobalt on the deoxyribonucleic acid biosynthesis and on the genetic information transmission in experimental animals. 2.effect on the serum protein biosynthesis and on embryonic development. *Rev Roum Biochim.* 21: 109-117.

FL Gavrilova, L. N. 1980. effect of cobalt salt supplements on protein accumulation in the liver and blood serum of broilers. *Sb. Nauch. Tr. Volgogr. S.-Kh. In-t.* 73: 100-2.

Nut def Gay, C. C., Gallina, A. M., Breeze, R. G., and White, R. L. 1983. ill-thrift in lambs. *Veterinary Medicine & Small Animal Clinician.* 78(3): 420-422.

Surv George, Joy and Nair, K. Prabhakaran . 1995. phosphorus and trace element status of anoestrous and repeat breeder cross bred cows. *Journal of Veterinary and Animal Sciences.* 26(2): 91-94.

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*

Acu Gilani, Shamshad H. New Jersey Medical School Newark and Alibhai, Yasmin New Jersey Inst of Technology Newark. teratogenicity of metals to chick embryos. *J Toxicol Environ Health. V30, N1, P23(9)*

Aquatic Goldberg, E. D. 1972. *Baseline Studies of Pollutants in the Marine Environment and Research Recommendations. NSF/IDOE-74-26*

Mix Gorbachev, V. T. 1992. [Efficiency of using vitamin and santochin in diets of bulls]: <original> ehffektivnost' ispol'zovaniya v ratsionakh bykov-proizvoditelej vitamina i santokhina. *Byulleten' Nauchnykh Rabot - Vsesoyuznyj Institut Zhivotnovodstva.* 107: 39-43.

FL Goryachev, I. I. and Krisyan, Ya. Yu. 1987. The effect of different doses of micronutrient cobalt on performance and reproductive function of cows: <original> vliyanie razlichnykh doz mikroehlementa kobal'ta na produktivnost' i vosproizvoditel'nuyu funktsiyu korov. *Zootekhnicheskaya Nauka Belorussii.* 28: 40-47.

Rev Goyer, R. A. 1996. Toxic Effects of Metals. In: Klaassen, C. D., Ed. Casarett and Doull's Toxicology: The Basic Science of Poisons. 691-736.

Mix Grace, N. D., Maunsell, L. A., and Scott, D. 1974. Growth responses of ewe hoggets supplemented with selenium copper cobalt and iodine in the lake ohau Area. *N Z J Exp Agric.* 2(2): 99-102.

Nut def Graham, T. W. 1991. Trace element deficiencies in cattle. *Veterinary Clinics of North America, Food Animal Practice.* 7(1): 153-215.

Unrel Greene, L. W. and Chirase, N. K. 1998. Influence of stocker program mineral nutrition on feedlot performance. *Compendium on Continuing Education for the Practicing Veterinarian.* 20(12): 1372-1379.

FL Gribovskii, G. P. 1973. Content of carotenoids in the liver of hens fed cobalt, manganese, and copper salts. *Profil. Zaraznykh Nezaraznykh Zabol. Zhivotn. Sib.* Mater. Nauch. Konf., Posvyashch. 50-letiyu Sib. NIVI (Nauch.-Issled. Vet. Inst.) (1973): Meeting Date 1971, 340-1. Editor(s): Kopyrin, A. V. Publisher: Sib. Nauch.-Issled. Vet. Inst., Omsk, USSR.

FL Gribovskii, G. P. 1971. (Effect of giving additional cobalt and manganese in the diet of henson their egg production). *Trudy Troitskogo Veterinarnogo Instituta* 14(No.2/3): 5-9.

Nut Def. Grice, H. C., Goodman, T., Munro, I. C., Wiberg, G. S., and Morrison, A. B. 1969. Myocardial toxicity of cobalt in the rat. *Ann N Y Acad Sci.* 156(1): 189-94.

FL Grin', N. V., Pavolvich, L. V., Govorunova, N. N., Bessmertnyi, A. N., and Besedina, E. I. 1992. Dynamics of the parameters of the functional state of albino rats when studying the systemic toxic effect of cobalt acetate. *Gig Sanit.* 0(11-12): 22-23.

Mix Grozhevskaya, S. B., Terekhina, A. N., and Terekhin, V. S. 1974. Effect of copper sulphate on reproduction in cattle and, in combinationwith cobalt chloride, on some biological processes in heifers. *Trudy Permskogo Sel'Skokhozyaistvennogo Instituta.* 103: 63-69.

Phys Guha, K. and Vanha-Perttula, T. 1983. Acid phosphatases in the mouse testis: activity changes during development. *Arch Androl.* 10(1): 7-16.

Mix Gusakov, K. and Sinkovets, A. 1998. Mineral additives. *Ptitsevodstvo.*(6): 27-28.

Bio Acc Hahn, Edmund, Hahn, Karin, and Ellenberg, Hermann. Heavy metal load in the feathers of magpies. *Verh. - Ges. Oekol. (1989)* : Volume Date 1988, 18, 317-24 .

Rev Hansard, S. L. 1983. Microminerals for ruminant animals. *Nutrition Abstracts and Reviews, B.* 53(1): 1-24.

In Vit Hasegawa, T., Hagiwara, Y., Saito, K., and Ozawa, E. 1982. Effect of transferrin on chick cell growth in-vitro and transferrin Receptor. *15th Annual Meeting of the Japanese Society of Developmental Biologists, Tokyo, May 27-29, 1982. Dev Growth Differ.* 29(4): 388.

In Vitro Hein, W., Roth, W., Schmidt, W., and Hellthaler, G. 1985. In-vitro studies for objectivation of acute cytotoxicity of orthopedic implants. *Beitr Orthop Traumatol* 32(10): 485-492.

Rev Henkens, C. H. and Koopman, J. J. 1973. *Tracing and Treating Mineral Disorders in Dairy Cattle.* 61pp.

Rev Henry, P. R., Ammerman, C. B., Baker, D. H., and Lewis, A. J. 1995. Cobalt bioavailability. *Bioavailability of Nutrients for Animals: Amino Acids, Minerals,and Vitamins* : 119-126.

Rev Henry, P. R., Littell, R. C., and Ammerman, C. B. 1996. Bioavailability of cobalt sources for ruminants 1: effects of time and dietary cobalt concentration on tissue cobalt concentration. *Nutrition Research.* 17(6): 947-955.

FL Herlin, A. H. and Andersson, I. 1996. *Soil Ingestion in Farm Animals. A Review.*

Abstract Hill, C. H. 1978. Effect of dietary protein levels on metal toxicity. *Federation Proceedings. 37 (3). 405*

CP Hill, C. H. 1981. the effect of iron and zinc on metal toxicities in the Chick. *65th Annual Meeting of the Federation of American Societies for Experimental Biology, Atlanta, Ga., Usa, April 12-17, 1981. Fed Proc. 40 (3 Part 1) 715.*

Rev Hill, C. H. 1980. Interactions of vitamin c with lead and mercury. *Annals of the New York Academy of Sciences* 355: 262-6.

Abstract Hill, C. H. 1975. The reduction of metal toxicities by ascorbic-acid in the chick. *FED PROC. Federation Proceedings. 34 (3). 926*

HHE Hindmarch, I. 1976. A subchronic study of the subjective quality of sleep and psychological measures of performance on the morning following night time medication with temazepam. *Arzneim-forsch.* 26(11): 2113-2116.

No Oral Hoey, M. J. 1966. The effects of metallic salts on the histology and functioning of the rat testis. *J Reprod Fertil.* 12(3): 461-472.

Nut def Holmes, J. H. G. 1992. Trace element deficiency in sheep in east gippsland, victoria. *Australian Veterinary Journal.* 69(11): 292-293.

Nut def Holmes, J. H. G., Edye, L. A., Potter, J., and Walton, E. 1986. Mineral status of beef cattle in papua new-guinea . *Trop Anim Health Prod.* 18(1): 31-39.

Bio Acc Honda, K., Ichihashi, H., and Tatsukawa, R. 1987. Tissue distribution of heavy metals and their variations with age sex and habitat in japanese serows capricornis-crispus. *Arch Environ Contam Toxicol.* 16(5): 551-562.

CP Hoshishima, K., Tujii, H., and Kano, K. 1978. Effects of the administration of trace amounts of metals to pregnant mice upon the behavior and learning of their offspring. *Proc Int Congr Toxicol 1ST 1977* .: 569-570.

Rev Howell, J. M., Masters, D. G., and White, C. L. 1996. Toxicities and excessive intakes of minerals. *Detection and Treatment of Mineral Nutrition Problems in Grazing Sheep.* 95-117.

Anat Huerta, M. and Stefani, E. 1981. Potassium and caffeine contractures in fast and slow muscles of the chicken. *Journal of Physiology (London). 318 (0): 181-190.*

Mineral Hutcheson, D. P. 1987. Minerals for feedlot Cattle. *Agri-practice.* 8(3): 3-6.

Nut def Ibragimov, Kh. Z., Norbaev, K. N., and Bakirov, B. B. 1984. Prevention of protein and mineral disorders during fattening of sheep. *Ovtsevodstvo.*(9): 37.

Bio Acc Ikebe, Katsuhiko, Nishimune, Takahiro, and Sueki, Kenji. 1994. Behavior of several elements in foods. vii. contents of 17 metal elements in food determined by inductively coupled plasma atomic emission spectrometry. meat and meat products. *Shokuhin Eiseigaku Zasshi* 35(3): 323-7.

Nut def Ivanov, V. I. 1995. Immunodeficiency condition of ayrshire cattle and its consequences: immunodefitsitnoe sostoyanie ajrshirskogo skota i ego posledstviya. *Veterinariya.* 12: 19-22.

Rev Izmerov, N. F. 1986. Cobalt. *Int Reg Potential Toxic Chem* . 100: 1-49.

No Oral Jalavisto, E., Kyllastinen, M., Kuorinka, I., and Haapiainen, T. 1966. Effect of cobalt on erythroid values, growth and oxygen consumption of the chick embryo and young chicken. *Ann Acad Sci Fenn [A].* 127: 1-15.

Food Jensen, L. S., Maurice, D. V., and Chang, C. H. Relation of mineral content of drinking water to liver lipid accumulation in laying hens. *Poult. Sci. (1977)* 56(1): 260-6.

CP Jilg, T. 1992. [Nutritive value and feed intake by growing cattle of the regrowth of extensively used sites in baden-wuerttemberg]. *[Ecological Aspects of Extensive Land Management] ; ISBN 3-922712-46-0* (35)

No Oral Johansson, A. and Camner, P. 1986. Adverse effects of metals on the alveolar part of the lung. *Scanning Electron Microsc.* 1986(2): 631-638.

Mix Judson, G. J., Brown, T. H., Kempe, B. R., and Turnbull, R. K. 1988. Trace element and vitamin b-12 status of sheep given an oral dose of one two or four soluble glass pellets containing copper selenium and cobalt. *Aust J Exp Agric.* 28(3): 299-306.

Mix Kabysh, A. A. and Komlev, M. D. 1966. Effect of cobalt and manganese salts on productivity, and on characteristics of the blood and bone tissues of hens in the southern ural region. *Tr. Troitsk. Vet. Inst. (1966)* 11(1): 51-6 .

FL Kal'nitskii, B. 1983. Mineral nutrition of young male cattle. *Molochnoe i Myasnoe Skotovodstvo.*(9): 34-36.

Unrel Kal'nitskii, B. D. 1984. Biological availability of manganese, iron and zinc from various compounds in young pigs. *Khimiya v Sel'Skom Khozyaistve.* 22(8): 45-48.

Nut def Kal'nitskii, B. D. 1986. Mineral nutrition of cattle. *Zhivotnovodstvo.*(7): 33-36.

Mix Kalinin, V. V., Epifanov, G. V., Zakachurin, A. F., Naumenko, P. A., and Ryzhkov, V. A. 1986. Fattening young cattle on distiller's grains. *Zhivotnovodstvo.*(2): 38-39.

Rev Kaminski, P. 1998. The impact of ca and heavy metals upon the nest development of sparrows (passer spp.) and other synanthropic birds . *Polish J Environ Stud.* 7(2): 53-65.

Surv Kaminski, P., Choinski, A., and Wolosiuk, B. 1993. Dynamics of the content of selected elements in the nestling development of the house martin delichon urbica in a rural landscape. *Acta Ornithologica (Warsaw).* 28(1): 23-37.

In Vit Kano, M. 1975. Development of excitability in embryonic chick skeletal muscle cells. *Journal of Cellular Physiology* 86(3 Pt 1): 503-10.

FL Karavashenko, V. F., Moskalik, A. E., Grishko, G. I., and Dovgopyata, L. N. 1985. tthe efficiency of cobalt supplementation of compound feeds for meat-type chicks: ehffektivnost' dobavok kobal'ta v kombikorma dlya myasnykh tsyplyat. *Byulleten' Vsesoyuznogo Nauchno-Issledovatel'Skogo Instituta Fiziologii, Biokhimii i Pitaniya Sel'Skokhozyajstvennykh Zhivotnykh.* 3(79): 53-56.

Rev Kawashima, T., Henry, P. R., Bates, D. G., Ammerman, C. B., Littell, R. C., and Price, J. 1997. Bioavailability of cobalt sources for ruminants 2: estimation of the relative value of reagent grade and feed grade cobalt sources from tissue cobalt accumulation and vitamin b-12 concentrations. *Nutrition Research.* 17(6): 957-974.

FL Kawecki, Arkadiusz, Rotenberg, Samuel, and Czajczynska, A. 1966 . The effect of cobalt and zinc on the growth and development of chickens. *Zesz. Nauk. Wyzsz. Szk. Roln. Szczecinie* : 20, 57-70 .

FL Kazakevich, I. Ya. and Vechar, A. S. 1978. Effect of cobalt on cobalamin content of liver and productivity of cattle. *Vestsi Akademii Navuk BSSR, Biyalagichnykh Navuk.*(1): 66-71, 140-141.

No Dose Keener, H. A., Percival, G. P., and Marrow, K. S. 1949. Cobalt tolerance in young dairy cattle. *J Dairy Sci.* 32: 527.

Unrel Kelley, Timothy R., Pancorbo, Oscar C., Merka, William C., Thompson, Sidney A., Cabrera, Miguel L., and Barnhart, Harold M. 1998. Accumulation of elements in fractionated broiler litter during re-utilization. *J. Appl. Poult. Res.* 7(1): 27-34 .

Nut def Kennedy, D. G., Blanchflower, W. J., Scott, J. M., Weir, D. G., Molloy, A. M., Kennedy, S., and Young, P. B. 1992. Cobalt-vitamin b-12 deficiency decreases methionine synthase activity and phospholipid methylation in sheep. *J Nutr.* 122(7): 1384-1390.

Nut def Kennedy, D. G., Cannavan, A., Molloy, A., O'Harte, F., Taylor, S. M., Kennedy, S., and Blanchflower, W. J. 1990. Methylmalonyl-coa mutase (ec 5.4.99.2) and methionine synthetase (ec2.1.1.13) in the tissues of cobalt-vitamin b12 deficient sheep. *British Journal of Nutrition.* 64(3): 721-732.

Nut def Kennedy, D. G(a), Young, P. B., Kennedy, S., Scott, J. M., Molloy, A. M., Weir, D. G., and Price, J. 1995. Cobalt-vitamin b-12 deficiency and the activity of methylmalonyl coa mutase and methionine synthase in cattle. *International Journal for Vitamin and Nutrition Research.* 65(4): 241-247.

Nut def Kennedy, D. Glenn(a), Kennedy Seamus, and Young Paul B. 1996. Effects of low concentrations of dietary cobalt on rumen succinate concentration in sheep. *International Journal for Vitamin and Nutrition Research.* 66(1): 86-92.

Nut def Kennedy, D. Glenn a, Young, Paul B, Blanchflower, W. John, Scott, John M, Weir, Donald G, Molloy, Anne M, and Kennedy, Seamus. 1994. Cobalt-vitamin b-12 deficiency causes lipid accumulation, lipid peroxidation and decreased alpha-tocopherol concentrations in the liver of sheep. *International Journal for Vitamin and Nutrition Research.*: 270-276.

FL Kenzhegalieva, M. A. and Baiturin, M. A. Effect of the level of a complex of trace elements (copper, manganese, cobalt, zinc, and iodine) on the growth and development of chicks in the semipalatinsk region. *Tr. Alma-At. Zoovet. Inst. (1974)* : 30, 34-7 .

Mix Khodyrev, A. A. and Volkonskii, V. A. 1986. Carbohydrate metabolism in young cattle on a diet containing varying amounts of iodine, cobalt and copper.: povyshenie effektivnosti zhivotnovodstva kalininskoioblasti. 50-54.

FL Kim, Y. K., Paik, I. K., Gangadharan, B., Rajan, A., Valsala, K. V., Mariamma, K. I., Miller, E. R., Lei, X., and Ullrey, D. E. 1993. the effects of sources and levels of supplementary copper on the performance of broiler chicken.: chemically induced copper depletion in ducks as a model for transdifferentiation study-preliminary observations: trace elements in animal nutrition. *KOREAN J ANIM SCI.* 35(1): 52-59.

FL Kirchgessner, M. and Pallauf, J. 1973. The effect of FE, CO and NI supplements in zinc deficiency. *Zeitschrift Fur Tierphysiologie Tierernahrung Und Futtermittelkunde.* 31(5): 268-274.

Phys Kirchgessner, M., Reuber, S., and Kreuzer, M. 1994. Endogenous excretion and true absorption of cobalt as affected by the oral supply of cobalt. *Biol Trace Elem Res.* 41(1-2): 175-89.

Mix Kirchgessner, M., Schwarz, F. J., and Stangl, G. I. 1998. Growth performance of beef cattle fed corn silage-based rations without cu, zn, mn, co and se supplementation. *Journal of Animal Physiology and Animal Nutrition.* 78(3): 141-153.

FL Trace element contents in fattening chicks 18 (6-7) : 527-32.

Surv Klimowicz Zbigniew, Melke Jerzy, and Uziak Stanislaw. 1997. peat soils in the bellsund region, spitsbergen. *Polish Polar Research* 18(1): 25-39.

Nut def Kline, E. A., Kostelic, G. C., Ashton, G. C., Homeyer, P. G., Quinn, L., and Catron, D. V. 1954. the effect of the growth performance of young pigs of adding cobalt, vitamin b12 and antibiotics to semipurified rations. *J Nutr.* 53: 543.

Drug Klosowski, B. 1971. the effect of gonadotropic hormones (pms) on gonadal function in rams subjected to deficiencies of copper and cobalt in the diet. *Zeszyty Problemowe Postepow Nauk Rolniczych.*(124): 187-191.

Phys Ko, Y. D., Cho, Y. H., and Shinn, S. J. 1976. experimental studies on the biosynthesis of vitamin b-12 in rabbit fed with inorganic cobalt. *Korean Cent J Med.* 30(1): 17-22.

FL Ko, Y. D., Song, D. J., and Ha, J. K. a. 1975. Effect of cobalt supplementation on the growth of young chicks: cobalt. *Korean Journal of Animal Science.* 17(1): 90-93.

Mix Kolganov, V. A., Latyshev, V. I., and Strugovshchikov, V. R. 1986. Effect of supplementary feeding with molybdenum-based trace elementmixtures on productivity of chickens and on thiamin content of theirorgans and tissues. *Fiziologicheskie Osnovy Povysheniya Produktivnostisel' Skokhozyaistvennykh Zhivotnykh.* 64-68.

FL Konopatov, Yu., Lipin, A., and Fedorov, V. 1991. Cobalt in the diet for broilers. *Ptitsevodstvo.*(11): 14-15.

FL Konopatov, Yu., Pilaeva, N., and Artem'eva, S. 1989. Cobalt and the resistance of chickens (to infection). *Ptitsevodstvo.*(8): 35-36.

Imm Konopatov, Yu V. 1992. Cobalt and immunogenesis in birds, as exemplified by the chicken. *Dokl Akad Nauk.* 322(4): 806-808.

FL Konopatov, Yu. V. 1992. Cobalt and immunogenesis in poultry. *Doklady, Biological Sciences.* 322(1-6): 54-55.

FL Konopatov, Yu. V. 1974. Effect of cobalt chloride on hen blood transaminase activity. *Sb. Rab., Leningr. Vet. Inst.* 36 : 53-7.

Unrel Koppl, C. and Gleich, O. 1988. Cobalt labelling of single primary auditory neurones: an alternative to hrp. *Hearing Research* 32(2-3): 111-6.

Mix Kornegay, E. T A, Zhou, W., and Risley, J. W. G. M. Swinkels and C R. 1995. Characterization of cobalt-copper antagonism in the study of copper-stimulated growth in weanling pigs. *Journal of Animal and Feed Sciences.* 4(1): 21-33.

Mix Korolev, A. 1987. A feed additive (for chickens). *Ptitsevodstvo* (9): 30-31.

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.

FL Krasovskii, G. N. and Fridliand, S. A. 1971. Experimental data for substantiating the maximum permissible concentration of cobalt in water: eksperimental'nye dannye k obosnovaniiu predel'no dopustimoi kontsentratsii kobal'ta v vodoemakh. *Gig Sanit.* 36(2): 95-6.

Aquatic Krasovskii, G. N. and Fridlyand, S. A. 1979. Experimental data for the valadation of the maximum permissable concentration of cobalt in water bodies. *Hyg. Sanit.* 36: 277-279.

Abstract Kravioskii, G. N., Wei-li Wang, K., and Baker, D. E. 1979. Experimental data for the validation of the maximum permissible concentration of cobalt in water bodies. *Hyg Sanit.* 36: 277-279.

Mix Kroc, M. and Vymola, J. 1990. Effect of vitamins and microelements in the high producing dairy cows feed rations. *Biol Chem Zivocisne Vyroby - Vet.* 26(4-5): 341-351.

Acute Krokhotina, L. V. and Pavlov, A. D. 1986. Effect of cobalt on blood gas composition red cell 2 3 diphosphoglycerate content and blood serum erythropoietin level. *PATOL FIZIOL EKSP TER.* 0(5): 65-67.

Surv Kucherova, F. N. and Besschetnov, I. I. 1981. Correlation between functional activity of hemopoietic organs and cobalt content in hen embryo. *S-KH BIOL .* 16(3): 454-458.

FL Kucherova, F. N. and Chorayan, O. G. 1983. Comparative informational characteristics of the microbiogenetic composition of reproductive cells in various animals. *Izv. Sev.-Kavk. Nauchn. Tsentra Vyssh. Shk. Estestv. Nauki* (4): 79-80 .

Not Oral Kury, George and Crosby, Roberta J. 1968. Development of chicken embryos exposed to cobaltous chloride. *Toxicol. Appl. Pharmacol.* 13(2): 199-206.

In Vitro Anodic oxidation under spark discharge (ANOD) - a new coating procedure in medical technology 41 (3) : 219-22.

FL Kuznetsov, S. G. 1996. Improvement of mineral nutrition for dairy cows. *Sel'Skokhozyaistvennaya Biologiya.* 0(6): 12-33.

Phys Lamand, M., Barlet, J. P., and Rayssiguier, Y. 1986. details of the clinical biology of minerals in Ruminants. *Recl Med Vet Ec Alfort.* 162(10): 1127-1132.

Alt Lara, S. I. M., Costa, H. M. de A., and Costa, J. O. 1974. Effect of supplementary feed on nematode egg counts, degree of parasite infestation and weight gain of lambs. *Arquivos Da Escola De Veterinaria Da Universidade Federal De Minas Gerais.* 26(3): 307-318.

Alt Lara, S. I. M., De, Oliveira C M B, and Porto, J. C. A. 1976. Effect of dietary supplementation with cobalt sulfate in experimental haemonchosis infection of sheep. *Arq Esc Vet Univ Fed Minas Gerais.* 28(1): 93-99.

Surv Larson, J. M., Karasov, W. H., Sileo, L., Stromborg, K. L., Hanbidge, B. A., Giesy, J. P., Jones, P. D., Tillitt, D. E., and Verbruggie D. A. 1996. Reproductive success, developmental anomalies, and environmental contaminants in double-crested cormorants (*Phalacrocorax auritus*). *Environm Toxicol Chem.* 15(4): 553-559.

FL Latyshev, V. I.//Ogarenko, N. B.//Rudenko, G. Ya.//Strugovshchikov, V. R. 1988. Effect of a complex of metals on some indicators of protein and energymetabolism in chickens. Tezisy dokladov. 256-257

FL Lebedeva, N. V. 1996. Population ecotoxicology of birds. *Doklady Akademii Nauk.* 351(3): 425-429.

Rev Lee, J., Masters, D. G., White, C. L., Grace, N. D., and Judson, G. J. 1999. Current issues in trace element nutrition of grazing livestock inaustralia and new zealand. *Australian Journal of Agricultural Research* 50(8): 1341-1364.

Unrel Lemerle, C. and Holmes, J. H. G. 1986. Sodium deficiency of grazing cattle in papua new-guinea. *Trop Anim Health Prod.* 18(3): 166-170.

FL Lempert, B. L., Avtandilov, G. G., and Levina, L. V. 1974. Effect of excess cobalt on nutritional hypercholesterolaemia, lipidosis of the aortae and arteries of the heart in rabbits. *Kardiologiya.* 14(1): 104-107.

FL Lempert, B. L. and Levina, L. V. 1974. effect of long-term feeding with toxic doses of cobalt on some lipid values in rabbits. *Farmakologiya i Toksikologiya.* 37(4): 466-469.

CP Levinson, W., Faras, A., Woodson, B., Jackson, J., and Bishop, J. M. 1973. Inhibition of rna-dependent dna polymerase of rous sarcoma virus by thiosemicarbazones and several cations. *Proceedings of the National Academy of Sciences of the United States of*

CP Lewis, G., Anderson, P. H., and Suttle, N. F. 1983. The nature of trace element problems: delineating the field problem. (Occasional Publication No. 7): 11-16.

HHE Li, Lan, Zhang, Ruling, Chen, Bingran, Fang, Weitang, Ye, Ping, and Ji, Qingxian. 1990. The nutritional study of zinc, iron, copper, and cobalt status of children in kindergartens of jinan city. *Yingyang Xuebao (1990)* 12(3): 294-8 .

Mix Likhachev, A. I. 1989. Trace elements in the etiology and prophylaxis of allergies of sheep in the caspian sea region. *Mikroelementy v SSSR.*(30): 90-93.

FL Lipnitskii, S. S. 1975. Effect of supplementary dietary trace elements on blood biochemical values of calves. *Trudy. Belorusskii Nauchno-Issledovatel'Skii Veterinarnyi Institut.* 13: 147-149.

Mix Lipnitskii, S. S. and Yakubovskii, M. V. 1975. Effect of additional dietary trace elements on weight gain and theoccurrence of various parasitic diseases in cattle in belorussia. *Trudy. Belorusskii Nauchno-Issledovatel'Skii Veterinarnyi Institut.* 13: 143-147.

Drug Livshits, O. D. 1987. Effect of dietary fiber from vegetable products on the content of sulfhydryl groups in the blood and organs of rats during cobalt poisoning: vliianie pishchevykh volokon ovoshchnykh produktov na soderzhanie sul'fgidril'nykh grupp v krovi i organakh krys pri kobal'tovoi intoksikatsii. *Gig Sanit.*(8): 72-3.

Drug Livshits, O. D. 1987. Effect of vegetable food fiber on liver function in chronic cobalt poisoning: vliianie pishchevykh volokon ovoshchei na funktsional'noe sostoianie pecheni pri khronicheskoi kobal'tovoi intoksikatsii. *Vopr Pitan* .(6): 64-5.

Drug Llobet, J. M., Domingo, J. L., and Corbella, J. 1985. Comparison of antidotal efficacy of chelating agents upon acute toxicity of co(ii) in mice. *Res Commun Chem Pathol Pharmacol.* 50(2): 305-8.

Nut def Lloyd Davies, H. a, Mann, P. P. b, and Goddard, B. c. 1989. A comparison of the effects of feed supplements, cobalt and selenium, and perennial and annual pastures on the production of medium peppin merino weaner sheep in south-western australia. *Australian Journal of Experimental Agriculture.* 29(3): 361-367.

Phys Lober, M. and Krantz, S. 1975. Chemical properties of plasma fibrinogens and fibrins from normal and cobalt-treated rabbits: untersuchungen uber einige chemische eigenschaften von plasma-fibrinogenen und -fibrinen normaler und kobaltbehandelter kaninchen. *Acta Biol Med Ger.* 34?710: 1573-88.

Phys Lopez-Guisa, J. M. and Satter, L. D. 1992. Effect of copper and cobalt addition on digestion and growth in heifers fed diets containing alfalfa silage or corn crop residues . *J Dairy Sci.* 75(1): 247-256.

FL Lotthammer, K.-H. and Ahlswede, L. 1973. Relationship between nutrition and fertility in cows. ii. effect of the major and trace elements. *Ubersichten Zur Tierernahrung.* 1(Heft 4): 325-353.

FL Lyakhov, V. V., Aminov, R. M., and Rakhmanov, M. 1977. Reserves for improving the reproduction of cattle. *Trudy Uzbekskogo Nauchno-Issledovatel'Skogo Instituta Zhivotnovodstva.*(28): 56-61.

FL Mackova, M. and Krchnak, C. 1978. Optimum amounts of cobalt in feeds for broiler ducklings. *Sbornik Vedeckych Praci Vyzkumneho Ustavu Vyzivy Zvirat, Pohorelice.* 12: 103-109.

FL Mackova, M., Sommerova, H., and Jurtikova, K. 1988. Effect of cobalt in feed on the blood picture, contents of vitamin a and vitamin b12 in liver and counts of escherichia coli in the caecum of growing ducklings. *Sbornik Vedeckych Praci Vyzkumneho Ustavu Vyzivy Zvirat Pohorelice.* 21: 83-92.

FL Mackova, M., Sommerova, H., and Kazdova, M. 1981. Effect of cobalt sulfate additives on the amount of vitamin b12 in the liver and cecum of Japanese quails. *Sb. Ved. Pr. Vyzk. Ustavu Vyz. Zvirat Pohorelice.* 15: 55-61.

Mix Macpherson, A., Moon, F. E., and Voss, R. C. 1976. Biochemical aspects of cobalt deficiency in sheep with special reference to vitamin status and a possible involvement in the etiology of cerebro cortical necrosis. *British Veterinary Journal.* 132(3): 294-308.

Drug MacPherson, A., N.F. Suttle, and others. 1983. Oral treatment of trace element deficiencies in ruminant livestock.. (Occasional Pub. 7): 93-103.

No Dose Macpherson, Allan. 1993. Recent developments in cobalt and selenium research. *Journal of the Science of Food and Agriculture.* 63(1): 104.

Unrel Mahaffey, K. R. 1977. Mineral concentrations in animal tissues certain aspects of federal drug administration regulatory role. *Journal of Animal Science 44 (3): 509-515.*

Drug Mahmoud, Alaaeldin and Parrish, John . 1996. Effects of Ni-2+, Co-2+ and La-3+ on bovine sperm capacitation by heparin. *South African Journal of Science.* 92(11-12): 564.

Phys Maines, M. D and Kappas, A. 1975. Study of the developmental pattern of heme catabolism in liver and the effects of cobalt on cytochrome p-450 and the rate of heme oxidation during the neonatal Period. *J. Exper. Med.* 141(6): 1400-1410.

Nut def Malestein, A. 1995. The problem of supplying cobalt to ruminants. *Tijdschrift Voor Diergeneeskunde.* 120(22): 644-646.

Mix Mallik, A. K. 1985. Effects of manganese deficiency in presence of excess cobalt and vice versa on serum lipoprotein profiles of rats receiving normal and atherogenic diets. *Indian J Biochem Biophys.* 22(4): 226-31.

No Dose Malzahn, E. 1983. Post natal changes in trace elements and in oxidation reduction activity in laboratory bank voles clethrionomys-glareolus. *Acta Theriol.* 28(1-8): 33-54.

Bio Acc Malzahn, E. 1981. Trace elements and their significance in the post natal development of seasonal generations of the bank vole clethrionomys-glareolus. *Acta Theriol.* 26(8-15): 231-256.

Nut def Marsakova, N. V. and Esipenko, B. E. 1990. Iodine, carbohydrate and protein metabolism in rats with cobalt deficiency: obmen ioda, uglevodov i belkov u krys pri defitsite v organizme kobal'ta. *Fiziol Zh.* 36(2): 43-50.

Nut def Marsakova, N. V. and Esipenko, B. E. 1990. Metabolism of iodine carbohydrates and proteins in rats with a cobalt deficiency. *Fiziol Zh (Kiev).* 36(2): 43-50.

No Oral Masters, D. G. and Peter, D. W. 1990. Marginal deficiencies of cobalt and selenium in weaner sheep response to supplementation. *Aust J Exp Agric.* 30(3): 337-342.

Nut def Mburu, J. N a, Kamau, J. M. Z., and Badamana, M. S. 1993. Changes in serum levels of vitamin b-12, feed intake, liveweight and hematological parameters in cobalt deficient small east african goats. *International Journal for Vitamin and Nutrition Research.* 63(2): 135-139.

Alt Mburu, N. J a, Badamana, M. S., and Kamau, J. M. Z. 1994. Faecal and urinary losses of nitrogen in cobalt-deficient small east african goats. *Indian Journal of Animal Sciences.* 64(11): 1264-1267.

Rev McDowell, L. R. 1985. Cobalt, iodine, and selenium. In: *Animal Feeding and Nutritionnutrition of Grazing Ruminants in Warm Climates*. 259-290.

Rev McDowell, L. R. 1985. Detection of mineral status of grazing ruminants. In: *Animal Feeding and Nutrition: Nutrition of Grazing Ruminants in Warm Climates.* 339-358.

Nut def Mcmeniman, N. P., Niven, D. R., Crowther, D., Gartner, R. F. W., and Murphy, G. M. 1981. Studies on the supplementary feeding of sheep consuming mulga acacia-aneura 5. the effect of cobalt and cottonseed meal supplementation. *Aust J Exp Agric Anim Husb.* 21(11): 404-409.

Mix Medvedskii, V. A. 1989. Protein composition in blood of pigs in relation to age and availability of biologically active substances. *Doklady Vsesoyuznoi Ordena Lenina i Ordena Trudovogo Krasnogo Znameni Akademii Sel'Skokhozyaistvennykh Nauk Im. V.I. Lenina.*(11): 43-46.

Mix Medvetskii, N. S. 1985. Some morphological and biochemical indicators in blood of young cattlegiven trace elements, vitamin a and ergocalciferol.: biologicheskie aktivnye veshchestva v ratsionakhsel'skokhozyaistvennykh zhivotnykh. 26-29.

Mix Medvetskii, N. S. and Koval', M. P. 1987. Natural immunity in young cattle in relation to the availability of trace elements and vitamins to their mothers.: biologicheski aktivnye veshchestva v kombikormakh ibelkovo-vitaminnye podkormki v ratsionakh sel'skokhozyaistvennykhzhivotnykh. 37-40.

Mix Mee, J. F., Rogers, P. A. M., and O'Farrell, K. J. a. 1995. Effect of feeding a mineral-vitamin supplement before calving on the calving performance of a trace element deficient dairy herd. *Veterinary Record.* 137(20): 508-512.

Mix Meged', S. S. 1985. Feed mixtures and concentrates for breeding ewes. *Zhivotnovodstvo.*(8): 39-41.

Nut def Mgongo, F. O. K. 1981. Malnutrition stimulation of steroid hormones and function of the mammary gland. *Tanzanian Veterinary Bulletin.* 3(3): 67-72.

Nut def Mgongo, F. O. K. 1988. Stress of nutritional origin and its effects on peripheral concentration of plasma hormones in goats. *Indian Vet J.* 65(6): 486-490.

Nut def Mgongo, F. O. K., Gombe, S., and Ogaa, J. S. 1985. Effects of cobalt deficiency on the ovarian function in the east african short-horned goat. *Beitrage Zur Tropischen Landwirtschaft Und Veterinarmedizin.* 23(2): 207-216.

Nut def Mgongo, F. O. K., Gombe, S., and Ogaa, J. S. 1984. The influence of cobalt-vitamin b-12 deficiency as a stressor affecting adrenal cortex and ovarian activities in goats. *Reprod Nutr Dev.* 24(6): 845-854.

FL Mikhailov, N. G. 1973. Feeding trace element salts to young mink in the magadan region. *Tr. Dal'Nevost. Nauchno-Issled. Inst. Sel'Sk. Khoz.* 13(2): 412-14.

FL Milanov, Z. 1995. Biological indication of the heavy metal pollution with the help of the hare (lepus europaeus Pall.). *Nauka Za Gorata.* 32(2): 59-65.

Rev Miller, E. R., Lei, X., and Ullrey, D. E. 1991. Chapter 16: Trace elements in animal nutrition. In: Mortvedt, J. J., F. R. Cox, L. M. Shuman et al., Eds. *Micronutrients in Agriculture*. 593-662.

Rev Miller, E. R., Lei, X., and Ullrey, D. E. 1991. Trace elements in animal nutrition. In: Mortvedt J. J., ET AL. ED., Ed. Soil Science Society of America Book Series, No. 4. *Micronutrients in Agriculture.* 593-662.

Nut def Mills, C. F. 1987. Biochemical and physiological indicators of mineral status in animals copper cobalt and zinc. *J Anim Sci.* 65(6): 1702-1711.

An Prod Milos, M., Contrea, A., Crista, N., and Rosu, Maria. 1970. Effect of chelation of trace minerals (manganese, copper, and cobalt) with edta on oxygen consumption in liver tissue and the activity of some enzymes of chicken serum. *Lucr. Stiint. Inst. Agron. Timisoara, Ser. Zooteh.* 13: 59-66 .

Mix Minina, L. A. 1983. Toxicological evaluation of multiple mineral premixes used for preventing the endemic diseases of sheep. *Trudy Vsesoyuznogo Instituta Eksperimental'Noi Veterinarii.* 58: 91-99.

Drug Mitala, J. J., Mann, D. E. Jr, and Gautieri, R. F. 1978. Influence of cobalt (dietary), cobalamins, and inorganic cobalt salts on phenytoin- and cortisone-induced teratogenesis in mice. *J Pharm Sci.* 67(3): 377-80.

Nut def Mitchell, P. J., McOrist, S., Thomas, K. W., and McCausland, I. P. 1982. White liver disease of sheep. *Australian Veterinary Journal.* 58(5): 181-184.

Nut def Mohammed, R. and Lamand, M. 1986. Cardiovascular lesions in cobalt-vitamin b-12 deficient Sheep. *Ann Rech Vet.* 17(4): 447-450.

FL Molchanov, I., Savran, E., and Mityaeva, M. 1973. Biological value of chicken meat. *Ptitsevodstvo* (11): 22.

Unrel 1986. The use of the chorioallantoic membrane (CAM) of the embryonic chick for the direct assessment of implant toxicity 13 (4) : 261-6.

No Oral Morelli, L., Di Giulio, C, Iezzi, M., and Data, P. G. 1994. Effect of acute and chronic cobalt administration on carotid body chemoreceptors responses. *Sci Total Environ.* 150(1-3): 215-

216.

Mix Morugin, A. K. and Iskov, V. V. 1984. Effect of the carbohydrate-and-mineral components of diets on growthand development of romanov ewes.: tezisy dokladov nauchno-proizvodstvennoi konferentsiipo aktual'nym voprosam veterinarii. 51-52.

Phys Murphy, J. and L'estrange, J. L. 1977. The performance and carcass fat characteristics of lambs fattened on concentrate diets part 1 effects of maize and barley as the cereal source and of dietary supplementation with roughage vitamin e cobalt and vitamin B-12. *Ir J Agric Res.* 16(2): 187-204.

FL Musbah, M., Harris, G. C. Jr., and Waldroup, P. W. 1978. The effects of supplementation of drinking water with zinc, molybdenum,and copper on skin fatty acids and dermatitis in broilers. *Poultry Science* 57(4): 1174.

Mix Muscalu, G., Grumberg, R., Ganea, M., Litinski, C., and Poleac, G. 1986. Improved performance of broiler chickens given chelated trace elementsin a mixed feed. *Revista De Cresterea Animalelor* 36(6): 14-20.

FL Nadeenko, V. G., Lenchenko, V. G., Saichenko, S. P., Arkhipenko, T. A., and Radovskaya, T. L. 1980. Embryotoxic action of cobalt administered by Mouth. *Gig Sanit.* 2: 6-8.

Rev NAS, Subcommittee on Mineral Toxicity Committee on Animal Nutrition. 1980.: 588.

Rev Neathery, M. W. and Miller, W. J. 1977. Tolerance levels, toxicity of essential trace elements for livestock and poultry. i. cattle and sheep. *Feedstuffs* . 49(36): 18-20, 34.

FL Nersisyan, S. N. 1971. Effect of some trace nutrients (zinc, manganese, copper, cobalt) on the growth and decelopment of chicks. *Izv. Sel'Skokhoz. Nauk* 14(8): 93-8 .

FL Nersisyan, S. N. 1971. Effect of some trace nutrients (zinc, manganese, copper, cobalt) on the growth and development of chicks. *Izv. Sel'Skokhoz. Nauk.* 14(8): 93-8.

Mix Nestorova, Yuliya a, Tsochev, Ivan a, Zunev, Penko a, and Nikolov, Ivan. 1997. Influence of some minerals on the sexual reflexes and sperm production of bucks. *Zhivotnov'Dni Nauki.* 34(7-8): 98-99.

Nut def Nicol, D. C. and Smith, L. D. 1981. Responses to cobalt therapy in weaner cattle in southeast queensland Australia. *Aust J Exp Agric Anim Husb.* 21(108): 27-31.

Unrel Nielsen, F. H. 1981. Consideration of trace element requirements for preparation of chemically defined Media. *The Growth Requirements of Vertebrate Cells in Vitro* : 68-81.

Mix Nikitin, A., Chemisova, L., Osipov, B., Kuz'mina, O., and Mel'nichuk, I. 1982 . Effect of trace elements on bone formation in pigs. *Svinovodstvo, Moscow, USSR.*(1): 35.

FL Nikolaev, E. M. 1974. Effect of biologically active substances on reproduction of mink females. *Tr. Beloruss. S-Kh. Akad.* 121: 158-61.

No Dose Nolte, T., Harleman, J. H., and Jahn, W. 1995. Histopathology of chemically induced testicular atrophy in rats. *Experimental and Toxicologic Pathology.* 47(4): 267-286.

Drug Norton, B. W., Cavaye, J. M., and Hales, J. W. a. 1990. Grazing management studies with australian cashmere goats, 4. cobalt supplementation and intestinal parasite burdens in sheep and goats in south-eastern queensland. *Australian Journal of Experimental Agriculture.* 30(6): 789-796.

Nut def Norton, B. W. and Hales, J. W. 1976. A response of sheep to cobalt supplementation in southeastern queensland australia. *Proc Aust Soc Anim Prod.* 11: 393-396.

No Dose Norton, B. W., Hales, J. W., and Stockwell, T. G. H. 1990. Reproduction, growth and survival of merino ewes and lambs in south-western queensland and their response to trace element supplementation. *Australian Journal of Experimental Agriculture.* 30(2): 155-163.

Mix Odynnets, R. N., Tokobaev, E. M., and Rubtsova, L. F. 1980. Effect of vitamin e, ammonium sulphate, salts of iodine, cobalt andcopper on mineral metabolism and histology of thyroid gland of wether sheep. *Mikroelementy v Zhivodnovodstve i Rastenievodstve, Frunze, USSR.*(No 18): 25-42.

Mix Olson, P. A. D. R. Brink D. T. Hickok M. P. Carlson N. R. Schneider G. H. Deutscher D. C. Adams D. J. Colburn and A. R. Johnson. 1999. Effects of supplementation of organic and inorganic combinations of copper, cobalt, manganese and zinc above nutrient requirement levels on postaprtum two-year-old cows. *Jounal of Animal Science.* 77: 522-532.

Not Avail Ostadalova, I., Babicky, A., Van Barneveld, A. A., Van den Hamer, C. J. A., and Houtman, J. P. W. 1983. Cataract in rats as a model of selective toxic action of selenium: drinking water hardness, trace elements and cardiovascular diseases: influence of calcium and magnesium on metabolism of cadmium, cobalt, copper, zinc, and selenium in mice. *Trace Subst. Environ. Health.* 16: 196-204.

Unrel Ott, E. A. and Asquith, R. L. 1995. Trace mineral supplementation of yearling horses. *J Anim Sci.* 73(2): 466-471.

FL Ozaki, M., Ishii, T., Funo, R., Torii, C., Ichiki, Y., and Hagiwara, Y. 1989. Effect of soil-eating on cobalt vitamin b-12 deficiency in lambs. *Bull Fac Agric Tamagawa Univ.* 0(29): 69-80.

Herp Padgaonkar, A. S. and Rangnekar, P. V. 1973. Observations following administration of alloxan and cobalt salts in the snake natrix-piscator. *J Univ Bombay.* 42(69): 63-75 .

Gene Palit, S., Sharma, A., and Talukder, G. 1991. Cytotoxic effects of cobalt chloride on mouse bone marrow cells in vivo. *Cytobios.* 68(273): 85-9.

FL Panova, M. K. 1967. Effect of trace element supplements on copper levels in fur-bearing wild animals. *Uch. Zap. Petrozavodsk. Gos. Univ.* 15(4): 78-81.

FL Panteleeva, M. D. 1975. Effect of trace element salts on the physiological state of chicks. Sb. Nauchn. Rab. Sib. Nauchno-Issled. Vet. Inst. (1975). 24, 115-18

FL Papesova, L. and Polasek, L. A. 1994. Modern trends in horse nutrition: moderni trendy ve vyzive koni. *Veterinarstvi.* 44(12): 591.

FL Paragon B-M. 1993. Readjustment of the supply of cobalt in the ruminant: critical approach. *Recueil De Medecine Veterinaire De L'Ecole D'Alfort.* 169(10): 759-761.

Nut Def Pehrsson, S. K., Hatori, N., Clyne, N., Kock, J., Lins, L. E., and Ryden, L. 1991. The effect of chronic cobalt exposure on cardiac function in Rats. *Trace Elem Med.* 8(4): 195-198.

Mix Peron, N., Martinez, G., Iglesias, C., and Morales, J. R. 1976. Effect of mineral, vitamin and protein supplements on the appearance ofoestrus in heifers fed a basic diet of sugar cane and molasses/urea. *Revista Cubana De Reproduccion Animal.* 2(2): 82-89.

Not Oral Pery-Man, N., Houeto, P., Coirault, C., Suard, I., Perennec, J., Riou, B., and Lecarpentier, Y. 1996. Hydroxocobalamin vs cobalt toxicity on rat cardiac and diaphragm aticmuscles. *Intensive Care Med.* 22(2): 108-15.

Unrel Peters, J. P. and Elliot, J. M. 1983. Effect of vitamin b-12 status on performance of the lactating ewe and gluconeogenesis from propionate. *J Dairy Sci.* 66(9): 1917-1925.

Alt Peters, J. P. and Elliot, J. M. 1984. Effects of cobalt or hydroxycobalamin supplementation on vitamin b-12content and (s)-methylmalonyl-coa mutase activity of tissue fromcobalt-depleted sheep. *J Nutr.* 114(4): 660-670.

FL Petrova, G. G. and Berestov, V. A. 1982. Effect of nutrition on the physiological status of fur-bearing animals. *Fiziol. Sostoyanie Pushnykh Zverei Puti Ego Regul.* 44-54 .

Mix Petryankin, F. P., Tukmakov, N., and Novikov, A. F. 1987. The effect of compound salts of trace elements on fertility of breeding bulls. *Veterinariya, Moscow.*(7): 59-60.

CP Phillippo, M., N.F. Suttle and others. 1983. The role of dose-response trials in predicting trace element deficiencydisorders.: trace elements in animal production and veterinarypractice. (Occasional Publicat. 7): 51-59.

CP Phillippo, M. and Suttle, N. F. 1983. The role of dose-response trials in predicting trace element deficiency disorders. In: *Trace Elements in Animal Production and Veterinary Practice*. 51-59.

Bio Acc Pinowski, J., Pinowska, B., Krasnicki, K., and Tomek, T. 1983. Chemical composition during growth in nestling rooks Corvus-frugilegus. *Ornis Scand.* 14(4): 289-298.

Surv Pisarski, R. K. 1988. Effect of dietary mineral content on serum mineral level in broiler chickens: wplyw skladnikow mineralnych paszy na zawartosc niektorych skladnikow nieorganicznych w osoczu krwi kurczat rzeznych. *Roczniki Nauk Rolniczych. Seria B - Zootechniczna: Polish Agricultural Annual. Seria B - Animal Science.* 104(3): 117-126.

FL Pisarski, R. K. 1988. Effect of the amounts of dietary minerals on the content of somemineral components in the blood plasma of broiler chickens. *Roczniki Nauk Rolniczych. Seria B, Zootechniczna* 104(3): 117-126.

FL Pisarski, R. K. Akademia Rolnicza Lublin Poland Inst. Zywienia i Higieny Zwierzat. 1988. [effect of dietary mineral content on serum mineral level in broiler chickens]. <original> wplyw skladnikow mineralnych paszy na zawartosc niektorych skladnikow nieorganicznych w osoczu krwi kurczat rzeznych. *Roczniki Nauk Rolniczych. Seria B - Zootechniczna. <Subtitle>Polish Agricultural Annual. Seria B - Animal Science. V. 104(3) P. 117-126*

Mix Plaur, K., Wojcik, S., Masiulanis, J., and Tyczkowski, J. 1983. Effect of trace elements on fattening performance of chickens givendiets with different protein and energy contents. *Roczniki Naukowe Zootechniki.* 10(2): 231-240.

FL Effect of trace elements on chicken fattening performance in relation to different protein and energy levels in the fodder 10 (2) : 231-40

Mix Plyashchenko, S. I., Sidorov, V. T., and Medvedskii, V. A. 1989. stimulation of productivity and immunity in sows. *Zootekhniya.*(1): 45-49.

Nut def Podkorytov, F. M., Nikitina, S. S., Kolchina, R. V., Dolenko, V. D., and Vinokurov, Yu. I. 1983. effect of a diet of reindeer moss (cladomia rangiferina) and concentrates on nutrient retention by reindeer.: diagnostika, profilaktika i terapiya bolezneizhivotnykh na krainem severe. 59-75.

Mix Pott, E. B., Tullio, R. R., Almeida, I. L. D., Brum, P. A. R. D., and Sousa, J. C. D. 1987. cattle reproductive performance in the paiaguas subregion of the brazilian pantanal ii. effect of mineral supplementation on heifers' reproductive Rates. *Pesqui Agropecu Bras.* 22(11-12): 1265-1278.

Surv Prasad, C. S., Sarma, P. V., Reddy, A. O., and Chinnaiya, G. P. 1989. Trace elements and ovarian hormonal levels during different reproductive conditions in crossbred cattle. *Indian Journal of Dairy Science.* 42(3): 489-492.

FL Puget, A., Vergnes, H., and Gouarderes, C. 1975. The sensitivity of the red pika (ochotona rufescens rufescens) to cobalt chloride: sensibilite de l'ochotone afgan (ochotona rufescens rufescens) au chlorure de cobalt. *Zentralbl Veterinarmed [A].* 22(7): 583-96.

Rev Pugh, D. G., Elmore, R. G., and Hembree, T. R. 1985. A review of the relationship between mineral nutrition and reproduction in cattle. *Bovine Pract.* 20: 10-13.

FL Pytloun, J., Alexa, Z., Markovic, P., Plickova, V., and Miskovsky, Z. 1974. Effect of cobalt supplement on growth and intake of nutrients by young bullocks during rearing. *Biologizace a Chemizace Vyzivy Zvirat.* 10(4): 369-378.

Nut def Quirk, M. F. and Norton, B. W. 1988. Detection of cobalt deficiency in lactating heifers and their Calves. *J Agric Sci.* 110(3): 465-470.

Mix Rakova, T. N. and Kondrat'ev, Yu. N. 1978. Growth of piglets from sows given a mineral supplement, and theirresistance to diarrhoea. *Veterinariya, Moscow, USSR.*(5): 90-92.

Rev Ramos, KS, Chacon, E, and Acosta Jr., D. 1996. Chapter 17: Toxic Responses of the Heart and Vascular Systems. In: Klaassen, Curtis D., Ed. Casarett and Doull's Toxicology: The Basic Science of Poisons. 487-527.

Unrel Rau, D. C. and Parsegian, V. A. 1992. Direct measurement of the intermolecular forces between counterion-condensed dna double helices. evidence for long range attractive hydration forces. *Biophysical Journal* 61(1): 246-59.

Phys Reddy, L. Y. S. and Reddy, S. M. 1988. Inter-relationship of some biochemical constituents in the blood serum of fertile and infertile cows. *Mysore J Agric Sci.* 22(3): 359-362.

No Oral Reichertova, E., Micek, J., Panakova, E., Koncekova, Z., and Cizmar, J. 1981. Effect of dust from magnesite works on avian embryo. *Folia Morphol(prague) 29:280-283* 29(280-283)

FL Reuber, S., Kreuzer, M., and Kirchgessner, M. 1993. Effect of cobalt depletion on growth and cobalt retention in organs and tissues of the rat. *Journal of Animal Physiology and Animal Nutrition.*: 129-138.

Acu Rhoads, K. and Sanders, C. L. 1985. lung clearance, translocation, and acute toxicity of arsenic, beryllium, cadmium, cobalt, lead, selenium, vanadium, and ytterbium oxides following deposition in rat lung. *Environmental Research* 36(2): 359-378.

FL Richet, G. 1972. *Trace Elements for Domestic Ruminants.* (Etude no. 51): 127 pp.

Bio Acc Rickard, W. H. and Sweany, H. A. 1975. *Radionuclides in Canada Goose Eggs. CONF-750985-*

1

No Oral Ridgway, L. P. and Karnofsky, D. A. 1952. The effects of metals on the chick embryo: toxicity and production of abnormalities in development. *Ann N Y Acad Sci.* 55: 203-215.

Nut Def Roginski, E. E. and Mertz, W. 1977. A biphasic response of rats to cobalt. *J Nutr.* 107(8): 1537-1542.

Nut def Rosa, I. V. 1993. Mineral deficiencies and reproductive performance of ruminants.: circular Tecnica - Centro Nacional De Pesquisa De Gadode Corte. (23): 46 pp.

No Oral Rosenberg, Daniel W. and Kappas, Attallah. 1989. Trace metal interactions in vivo: inorganic cobalt enhances urinary copper excretion without producing an associated zincuresis in rats. *J. Nutr.* 119(9): 1259-68 .

Nut def Roslyakov, A. K., Baiturin, M. A., and Aryngaziev, B. 1970. Reaction of ewe lambsfon the kazakh fine wooled breed to enrichment of their rations with mineral salts sodium phosphorus cobalt copper and iodine. *Tr Alma-at Zootekh-vet Inst.* 18: 73-80.

Phys Roy, R. K., Banerjee, S. K., Majumder, P. K., Sasmal, N., and Chatterjee, G. C. 1973. Effects of manganese cobalt and molybdenum on ascorbic-acid metabolism and other related pathways in control and ascorbic-acid deficient guinea pigs. *Indian J Biochem Biophys.* 10(3): 202-205.

Unrel Ruff, M. D., <Editors> McDougald, L. R., Joyner, L. P., and Long, P. L. 1986. Reasons for inadequate nutrient utilization during avian coccidiosis: areview. 169-185.

Nut Def Ryan, T. 1991. Trace elements and their role in avian nutrition. *Canine Pract.* 16(2): 30-35.

In Vit Saito, K., Hagiwara, Y., Hasegawa, T., and Ozawa, E. 1982. Indispensability of iron for the growth of cultured chick cells. *Development Growth & Differentiation.* 24(6): 571-580.

Mix Sapozhkov, S. V. 1982. Effect of cobalt and nickel on histological changes in the nervous system. *Sbornik Nauchnykh Trudov Leningradskogo Veterinarnogo Instituta.*(71): 102-108.

FL Sasse, C. 1990. *Effect of a Cobalt-Containing Mineral Supplement on the Performance of AI Bulls.*: 87 pp.

FL Sato, Y. 1973. The effect of cobalt in diet on nutrition and incidence of dental caries in rat. *Shikwa Gakuho.* 73(5): 956-8.

Alt Saxena, K. K. and Ranjhan, S. K. 1978. Effect of cobalt and copper supplementation separately and in combination on the digestibility of organic nutrients and mineral balances in hariana calves. *Indian J Anim Sci.* 48(8): 566-571.

Phys Saxena, K. K., Srivastava, R. V. N., Srivastava, S. K., and Ranjhan, S. K. 1980. Effect of cobalt and copper supplementation on the ruminal volatilefatty acids concentration and microbial population in hariana calves. *Indian Journal of Animal Sciences.* 50(6): 471-475.

Nut def Schottler, J. H., Boromana, A., and Williams, W. T. 1977. Comparative performance of cattle and buffalo on the sepik plains papua new-guinea. *Aust J Exp Agric Anim Husb.* 17(87): 550-554.

Rev Schubert, J. 1973. Heavy metals--toxicity and environmental pollution. *Adv Exp Med Biol.* 40: 239-97.

Unrel Seekles, L. 1972. Mineral trace elements and animal reproduction.: riproduzione animale e fecondazione artificiale. 299-307.

Mix Shavkun, V. E., Khavinzon, A. G., Shalovilo, S. G., and Zhminka, V. Ya. 1979. The effect of biologically active substances on reproductive function of sires. *Zhivotnovodstvo.*(11): 60-62.

Unrel Sheng, Y. Z., Liang, M. L., Wang, Q. X., Dong, K. Y., Tang, Y. H., and Sheng, M. X. 1986. Effect of methionine and trace element supplements on the rate of woolgrowth in angora rabbits. *Chinese Journal of Rabbit Farming (Zhongguo Yangtu Zazhi).*(3): 39-42.

Mix Shkunkova, Yu. S.//Tkachuk, V. G. 1974. Effect of trace elements on the growth of chickens and the productivityof hens. *Khimiya v Sel'skom Khozyaistve*. 12 (8) : 614-616

Mix Shubin, A. A. 1986. The effect of biologically active substances on reproductive function and productivity of cows. *Zhivotnovodstvo.*(10): 43-44.

FL Shubin, A. A. 1968. Influence of iodine and cobalt salts on reproductive capacity of cows. *Byull Vses Nauch-issled Inst Fiziol Biokhim Sel'skokhoz Zhivotn.* 1: 74-77.

FL Shvelidze, N. E. 1981. New resources for the production of grass meal for broilers. *Vestnik Sel'Skokhozyaistvennoi Nauki, Moscow, USSR* (10): 29-33.

Mix Sidorova, M. V. and Morozova, N. N. 1986. Kidney histostructure in young bulls fed with distillery grains with the use of trace Elements. *Izv Timiryazev S-kh Akad.* 0(5): 155-160.

FL Simek, M. 1995. Recommended requirements of mineral substances and their resources in cattle and sheep: Doporucene Potreby Mineralnich Latek a Jejich Zdroje U Skotu a Ovci.

Nut Def Singh, K. K., Chhabra, A., and Agrawal, R. K. 1997. Influence of dietary cobalt on blood constituents and metabolites in crossbred calves. *Indian Journal of Animal Nutrition.* 14(3): 196-198.

Mix Singh, K. K a and Chhabra, Aruna. 1996. Influence of cobalt supplementation on growth, and utilization of urea in crossbred calves. *Indian Journal of Animal Nutrition.* 13(1): 11-14.

Acute Singh, P. P. and Junnarkar, A. Y. 1991. Behavioural and toxic profile of some essential trace metal salts in mice and Rats. *Indian J Pharmacol.* 23(3): 153-159.

FL Sirotkin, A. N., Prister, S. S., Tyumenev, L. N., and Grishin, A. I. 1979. Metabolism of 60co, 65zn, 59fe and 3h in the hen. *Doklady Vsesoyuznoi Ordena Lenina Akademii Sel'Skokhozyaistvennykh Nauk* (6): 27-29.

FL Skare, J. U. 1995. Environmental toxicology research at a veterinary college-veterinary institute. *Norsk Veterinaertidsskrift.* 107(4): 363-376.

Phys SLowinska, R., Sobiech, K. A., Ziomek, E., and Szewczuk, A. 1978. activity and polymorphism of the cobalt-activated acylase in tissues of rodents during development. *Acta Biochim Pol.* 25(1): 15-21.

Plant Smirnova, Z. A. 1970. Use of trace nutrients to increase the growth of plants and the soil germination rate of seeds of some introduced varieties *Tr. Kaz. Nauch.-Issled. Inst. Les. Khoz.* 7, 203-6.

Fate Snively, W. D. Jr and Becker, B. 1968. minerals, macro and micro: dynamic nutrients. ii. the micro-minerals. *Ann Allergy.* 26(5): 233-40.

Mix Sobolev, N. 1995. belotin. *Ptitsevodstvo.*(5): 20.

FL Sominskii, Z. F. and Nikitina, L. P. 1978. Morphological reaction of the liver of hens after administration of various doses of cobalt chloride and manganese sulfate. *Profilakt. i Lechenie Boleznei S.-Kh. Zhivotnykh, Ul'Yanovsk.*: 64-8.

Rev Sourkes, T. L. 1982. Transition elements and the nervous System. *Iron Deficiency: Brain Biochemistry and Behavior. ILLUS. ISBN 0-89004-690-5.* 1-30.

Acute Spiridonova, V. S. and Shabalina, L. P. 1973. Experimental study of the toxicity of cobalt tetracarbonyL. *Gig Sanit.* 38(1): 97-9.

FL Splitek, M. 1982. Micro-mineral nutrition of poultry: mikromineralni vyziva drubeze. *Krmivarstvi a Sluzby.* 18(11): 238-240.

FL Splitek, M. Vyzkumny Ustav Krmivarskeho Prumyslu a Sluzeb Pecky Czechoslovakia. 1982. micro-mineral nutrition of poultry. <original> mikromineralni vyziva drubeze. *Krmivarstvi a Sluzby. V. 18(11) P. 238-240*

Nut def Squires, R. A. and Budge, G. 1997.*Proceedings From the 27th Seminar of the Society of Sheep and BeefCattle Veterinarians NZVA.* (175): 1-151.

Plant Staaland, Hans//Brattbakk, Ingvar//Ekern, Karen//Kildemo, Kjetil. 1983. Chemical composition of reindeer forage plants in Svalbard and Norway. *Holarctic Ecol*. 6 (2) : 109-22.

Surv Stafford, Kevin J. 1997. The diet and trace element status of sambar deer (*Cervus unicolor*) in manawatu district, New Zealand. *New Zealand Journal of Zoology.* 24(4): 267-271.

FL Stan, Mariana. 1969. Cobalt chloride effect on liver, thyroid, and thymus in chicken. *Rev. Zooteh. Med. Vet.* 19(4): 84-9.

Nut def Stangl, G. I., Schwarz, F. J., and Kirchgessner, M. 1998. Amino acid changes in plasma and liver of cobalt-deficient cattle. *Journal of Animal Physiology and Animal Nutrition.*: 40-48.

Unrel Stanojevic, Lazar. 1972. *Trans. of Arhiv Za Poljoprivredne Nauke i Tehniku (Yugoslavia).* 24(88): 115 p.

Model Stebbings, R. St. J. and Lewis, G. 1986. Cobalt deficiency and urinary formiminoglutamic acid in lambs. *British Veterinary Journal.* 142(3): 270-274.

FL Stelletskii, V. V. and Korkunov, Yu. P. Trace element requirement of adult chickens. *Tr. Krasnoyarsk. Nauch.-Issled. Inst. Sel. Khoz. (1969)* : 5, 288-300.

FL Stepurin, G. F., Bularga, I. A., Vranchan, V. G., and Korchevaya, L. G. 1986. Interaction of energy, protein, amino acids and trace elements in Pignutrition.: Belkovo-aminokislotnoe Pitanie Sel'skokhozyaistvennykhzhivotnykh. Tezisy, Doklady Vsesoyuznogo Soveshchaniya, Kaluga, 28-30may, 48-50.

Phys Stillions, M. C., Teeter, S. M., and Nelson, W. E. 1971. Utilization of dietary vitamin b-12 and cobalt by mature horses. *J Anim Sci.* 32(2): 252-255.

FL	Stoimenov, K. 1976. Effect of some microelements on heterakis gallinarum infection. *Veterinarnomeditsinski Nauki* 13(2): 5-11.
Nut def	Stokstad, E. L. 1968. Experimental anemias in animals resulting from folic acid and vitamin b12 deficiencies. *Vitam Horm.* 26: 443-63.
HHE	Stoliar, V. I. 1972. Congenital disorders in the presence of nutritional microelement deficiencies: vrozhdennye narusheniia pri alimentarnom defitsite mikroelementov. *Pediatriia.* 51(10): 75-8.
Alt	Stomakhina, N. V., Kogan, V. Yu, Sarkisyan, M. A., and Danilova, M. K. 1991. The study of the role of immunomodulatory activity of metal salts in the development of allergic skin pathology. *Eksp Klin Med.* 31(2): 173-176.
In Vit	Suarez-Isla, B. A., Pelto, D. J., Thompson, J. M., and Rapoport, S. I. 1984. Blockers of calcium permeability inhibit neurite extension and formation of neuro muscular synapses in cell culture. *Developmental Brain Research. 14 (2). 263-270.*
Mix	Sumadi, Lebdosoekojo, and Latif, A. 1982. The effects of vermifuge and cobalt administration on the growth of brachman crossbreed and ongole cattle at the 'Bila River Ranch' South Sulawesi: Proceedings of a Seminar on Animal Research 401-405.
Mix	Surina, S. M. and Tabakov, N. A. 1989. The effect of balanced feed rations on milk yield, reproduction andmetabolism in Cows.: Intensifikatsiya Zhivotnovodstva V Khakassii. 61-63.
Bio Acc	Suso, F. A. and Edwards, H. M. Jr. 1969. Whole body counter studies on the absorption of 60co, 59fe, 54mn and 65zn by chicks, as affected by their dietary levels and other supplemental divalent elements. *Poultry Science* 48(3): 933-8.
Review	Suso, Francisco A. and Edwards, Hardy M. Jr. 1968. Influence of various chelating agents on absorption of cobalt-60, iron-59, manganese-54, and zinc-65 by chickens. *Poultry Sci.* 47(5): 1417-25 .
Mineral	Suttle, M. and Jones, D. G. 1989. Recent developments in trace element metabolism and function trace elements disease resistance and immune responsiveness in ruminants. *J Nutr.* 119(7): 1055-1061.
CP	Suttle, N., Wright, C., MacPherson, A., Harkess, R., Halliday, G., Miller, K., Phillips, P., and Evans, C. 1986. How important are trace element deficiencies in lambs on improved hill pastures in scotland. *Proceedings Sixth International Conference on Production Disease in Farm Animals, September 1986, Belfast, UK* : 100-103.
Phys	Suttle, N. F. 1986. Problems in the diagnosis and anticipation of trace element deficiencies in grazing livestock. *Veterinary Record.* 119(7): 148-152.
CP	Suttle, N. F., Gunn, R. G., Allen, W. M., Linklater, K. A., and Wiener, G. 1983. Trace elements in animal production and veterinary practice. Proceedings of a symposium organized jointly by the British Society of Animal Production and the British Veterinary Association and held at the University of York in July 1982. ix + 155pp.
Mix	Svezhentsov, A. and Gavrish, A. 1994. A feed supplement - soevit. *Ptitsevodstvo.*(3): 25-27.
CP	Szakmary, E., Ungvary, G., Naray, M., Mede, A., Tatrai, E., and Morvai, V. 1989. Harmful effects of heavy metals chromium nickel cobalt on offspring. 17th Conference of the European Teratology Society. Budapest, Hungary, September 4-7, 1989. Teratology; 40 (3). 1989. 298-299.

Bio Acc Szefer, P. and Falandysz, J. 1987. Trace metals in the soft tissues of scaup ducks (*Aythya marila l.*) wintering in Gdansk bay, Baltic sea . *Sci Total Environ.* 65: 203-213.

FL Tanatarov, A. B. 1983. Trace elements for broiler chickens. *Zhivotnovodstvo* (5): 47-48.

FL Tanatarov, A. B. 1986. Trace elements in duck feeding. *Zhivotnovodstvo.*(2): 44-45.

FL Tanatarov, A. B. 1986. Trace elements in the feeding of ducklings. 1986. *Zhivotnovodstvo.* (2) : 44-5.

FL Tanatarov, A. B. and Baiturin, M. A. 1972. Determination of the optimum dose of iodine and cobalt for laying hens. *Tr. Alma-At. Zoovet. Inst.* 24: 120-7.

FL Tanatarov, M. A., Egorov, N. P., Tanatarov, A. B., Egeubaev, A. A., and Dabzhanova, S. T. Effect of trace elements on productive qualities of muscovy ducks. *Vestn. S-Kh. Nauki Kaz. (1994)* (5): 64-72 .

Unrel Tauson, Anne-Helene a and Neil, Maria. 1993. Vitamin b12 supplementation to mink (mustela vison) in the prevention of feed-induced iron deficiency anaemia: ii. effect on haematological parameters and mineral content of the liver. *Acta Agriculturae Scandinavica Section A Animal Science.* 43(2): 123-128.

No Oral Telib, M. 1972. Effects of cobaltous chloride in laboratory animals part 1 the histological and electron microscopical changes in the islets of rabbits. *Endokrinologie.* 60(1): 81-102.

In Vitro Telib, M. 1972. The purification and properties of nucleoside phosphotransferase from mucosa of chicken intestine. *Endokrinologie.* 786 (3) : 231-44.

Alt Thomson, C. M. and Dryden, W. F. 1981. Different actions of calcium channel blocking agents on resting membrane conductance in developing skeletal muscle. *Canadian Journal of Physiology and Pharmacology. 59 (4): 335-341.*

No Dose Thurston, R. J., Korn, N., Froman, D. P., and Bodine, A. B. 1993. Proteolytic enzymes in seminal plasma of domestic turkey (*Meleagris gallopavo*). *Biology of Reproduction* 48(2): 393-402.

FL Tkachenko, A. V. 1995. Hemoxygenase activity, metabolic homeostasis of bilirubin in brain and transport function of serum albumin in animals receiving cobalt chloride. *Eksperimental'Naya i Klinicheskaya Farmakologiya.*: 41-45.

FL Tolokonnikov, Yu., Orlov, L., Pisarskaya, T., Nikil'burskii, N., and Stratiichuk, A. 1985. Utilization of colloidal jellyfish during fattening of broilers. *Ptitsevodstvo* (3): 29.

Nut def Tseng, R. Y., Cohen, N. L., Reyes, P. S., and Briggs, G. M. 1976. Metabolic changes in golden hamsters fed vitamin b-12-deficient diets. *J Nutr.* 106(1): 77-85.

No Oral Tsujii, H. and Hoshishima, K. 1979. Effect of the administration of trace amounts of metals to pregnant mice upon the behavior and learning of their offspring. *Shinshu Daigaku Nogakubu Kiyo(j Fac Agric Shinshu Univ)* . 16: 13-28.

Abstract Turk, J. L Jr. and Kratzer, F. H. 1960. The effects of cobalt in the diet of chicks. *Poult Sci.* 39: 1302.

Not Oral Turner, W. B, Corp, E. S, and Galbraith, R. A. 1994. Lack of npy-induced feeding in cobalt protoporphyrin-treated rats is a postreceptor defect. *Physiology & Behavior* 56(5): 1009-1014.

Mix Ulvund, M. J. 1990. Ovine white-liver disease owld serum copper and effects of copper and selenium supplementation. *ACTA VET SCAND.* 31(3): 287-296.

Nut def Ulvund, M. J. 1990. Ovine white-liver disease owld vitamin b-12 and methyl malonic acid mma estimations in blood. *Acta Vet Scand.* 31(3): 267-276.

Surv Ulvund, M. J. and Pestalozzi, M. 1990. Ovine white-liver disease owld botanical and chemical composition of pasture grass. *Acta Vet Scand.* 31(3): 257-266.

Unrel Underwood, E. J. 1976. Mineral imbalances in farm animals and their study and diagnosis with isotopic tracers. *Atomic Energy Review* 14(4): 591-619.

Rev Underwood, E. J. 1981. *The Mineral Nutrition of Livestock*. ix + 180pp.

CP Underwood, E. J. 1977. *Trace Elements in Human and Animal Nutrition.* 4th Edition. New York.

FL Ustinskova, L. A. 1979. Change in the chemical composition of turkey bones in connection with age and physiological state. *Nauchn. Tr. Kazan. Gos. Vet. Inst. im. N. E. Baumana.* 131, 78-80.

FL Vakhitova, R. Z. 1978. Effect of cobalt (in feed rations) on protein indicators of blood in the process of duck growth. *Vestnik Sel'Skokhoziaistvennoi Nauki Kazakhstana. Ezhemesiachnyi Nauchnyi Zhurnalkazakh S.s.r. ; Ministerstvo Sel'Skogo Khoziaistva.* 21(4): 114-116.

CP Vallee, B. L. The entatic properties of cobalt carboxypeptidase and cobalt procarboxypeptidase. *IN: Trace Element Metabolism in Animals - 2* : 5.

Mix Valyushkin, K. D. 1982. Combined use of vitamins and trace elements and the reproductive function of Cows. *Vyestsi Akad Navuk Bssr Syer Syel'skahaspad Navuk.* 0(2): 68-71.

Mix Van Ryssen, J. B. J., Miller, W. J., Gentry, R. P., and Neathery, M. W. 1987. Effect of added dietary cobalt on metabolism and distribution of radioactive selenium and stable minerals. *J Dairy Sci.* 70(3): 639-644.

Mix Van Vleet, J. F. 1982. Amounts of 8 combined elements required to induce selenium vitamin e deficiency in ducklings and protection by supplements of selenium and vitamin E. *Am J Vet Res.* 43(6): 1049-1055.

Mix Van Vleet, J. F. 1982. Amounts of twelve elements required to induce selenium vitamin e deficiency in ducklings. *Am. J. Vet. Res.* 43(5): 851-857.

Mix Van Vleet, John F.Van Vleet, J. F. 1982. Amounts of eight combined elements required to induce selenium-vitamin E deficiency in ducklings and protection by supplements of selenium and vitamin E. *Am. J. Vet. Res*. 43 (6) : 1049-55.

Nut def Vellema, P a, Moll, L., Barkema, H. W., and Schukken, Y. H. 1997. Effect of cobalt supplementation on serum vitamin b-12 levels, weight gain and survival rate in lambs grazing cobalt-deficient pastures. *Veterinary Quarterly.* 19(1): 1-5.

In Vit Verger, C., Sassa, S., and Kappas, A. 1983. Growth promoting effects of iron proto porphyrins and cobalt proto porphyrins on cultured embryonic cells. *Journal of Cellular Physiology. 116 (2): 135-141.*

Unrel Vishnyakov, S. I. and Moskovchenko, L. A. 1978. Ion antagonism and onset of diseases and a disturbance in metabolism in farm animals. *Probl. Vzaimodeistviya Chelovka s Okruzh. Sredoi. Materialy Vses. Soveshch., Kursk.*: 156-8.

Mix Volobueva, R. A. and Khadanovich, I. V. 1983. Vitamin b-12 and cobalt in diets for young pigs. *Khimiya v Sel'Skom Khozyaistve.* 20(7): 43-44.

Rev Watson, A. and O'Hare, P. J. 1979. Red grouse populations on experimentally treated and untreated irish bog. *J Appl Ecol.* 16(2): 433-452.

Acu Wellman, P. J., Watkins, P. A., Nation, J. R., and Clark, D. E. 1984. Conditioned taste aversion in the adult rat induced by dietary ingestion of cadmium or cobalt. *Neurotoxicology.* 5(2): 81-90.

Nut def Whanger, P. D. and Weswig, P. H. 1978. Influence of 19 elements on development of liver necrosis in selenium and vitamin e deficient rats. *Nutr Rep Int.* 18(4): 421-428.

Nut Def Whanger, P. D., Weswig, P. H., Schmitz, J. A., and Oldfield, J. E. 1976. Effects of selenium, cadmium, mercury, tellurium, arsenic, silver and cobalt on white muscle disease in lambs and effect of dietary forms of arsenic on its accumulation in tissues. *Nutr Rep Int.* 14(1): 63-72.

No Oral Wide, M. 1984. Effect of short-term exposure to five industrial metals on the embryonic and fetal development of the mouse. *Environ Res.* 33: 47-53.

Nut Def Winter, W. H., Siebert, B. D., and Kuchel, R. E. 1977. Cobalt deficiency of cattle grazing improved pastures in northern cape york peninsula. *Aust J Exp Agric Anim Husb.* 17(84): 10-15.

Phys Wise, W. R., Weswig, P. H., Muth, O. H., and Oldfield, J. E. 1968. Dietary interrelationship of cobalt and selenium in lambs alfalfa-d white muscle disease. *J Anim Sci.* 27(5): 1462-1465.

Acute Wohllebe, W., Taube, C., and Fiedler, H. 1968. Behavior of thrombin time, activities of antithrombin ii and 3 following administration of cobalt (ii) compounds in rabbits: das verhalten der thrombinzeit, der aktivitaten von antithrobmin ii and 3 nach parenteraler verabreichung von kobalt (ii)-verbindungen an kaninchen. *Z Gesamte Inn Med.* 23(17): 537-9.

Alt Wolford, J. H. and Murphy, D. 1972. Effect of diet on fatty liver-hemorrhagic syndrome incidence in laying chickens. *Poultry Sci.* 51(6): 2087-94.

Phys Woods, J. S. 1976. Developmental aspects of hepatic heme biosynthetic capability and hematotoxicity. *Biochem Pharmacol.* 25(19): 2147-52.

Phys Woods, J. S. and Carver, G. T. 1977. Action of cobalt chloride on the biosynthesis, degradation and utilization of heme in fetal rat liver. *Drug Metab Dispos.* 5(5): 487-492.

In Vit Wyler, R. and Wiesendanger, W. 1975. The enhancing effect of copper, nickel, and cobalt ions on plaque formation by semliki forest virus (sfv) in chicken embryo fibroblasts. *Archives of Virology* 47(1): 57-69.

Acute Yamaguchi, M., Inamoto, K., and Suketa, Y. 1986. Effect of essential trace metals on bone metabolism in weanling rats: comparison with zinc and other metals' actions. *Res Exp Med (Berl).* 186(5): 337-42.

Unrel Yamaguchi, M. and Yamaguchi, R. 1986. Action of zinc on bone metabolism in rats. increases in alkaline phosphatase activity and dna content. *Biochem Pharmacol.* 35(5): 773-7.

Acute Yi, S. and Maines, M. D. 1990. Heme oxygenase 2 messenger rna developmental expression in the rat liver and response to cobalt chloride. *Arch Biochem Biophys.* 282(2): 340-345.

Mix Zervas, G., Telfer, S. B., Al-Tekrity, A., and Jones, D. 1987. Prevention of trace element deficiencies in grazing ruminants. II. sheep. *Deltion Tes Ellenikes Kteniatrikes Etaireias = Bulletin of the Hellenic Veterinary Medical Society.* 38(4): 258-263.

FL Zharova, E. P. 1970. Age dynamics of the levels of copper, zinc, manganese, and cobalt in the muscles of white russian chickens. *Timiryazev. Sel'Skokhoz. Akad* : No. 157, 247-50 .

Bio Acc Zharova, E. P. 1969. Level of some trace elements in a growing chick embryo Dokl. Tskha (Timiryazev. Sel'skokhoz. Akad.) No. 151, 199-202

Mix Zhou, W., Swinkels, J. W. G. M., Risley, C. R., and Kornegay, E. T. 1992. Ability of cobalt to reduce copper deposition in selected tissues of weanling pigs fed growth promoting level of copper. *Animal Science Research Report, Virginia Agricultural Experiment Station.*(10): 44-46.

FL Zivkovic, R., Kostic, V., and Velickovic, G. 1972. Effect of trace elements (cu, co) on production and reproduction of ewes. *Savremena Poljoprivreda.* 20(2): 5-12.

Mix Zlobina, I. E. and Skukovskii, B. A. 1990. effect of dietary trace element level on physiological and productiveindicators in broiler chickens. *Nauchno-Tekhnicheskii Byulleten', VASKhNIL, Sibirskoe Otdelenie: Sibirskii Nauchno-Issledovatel'Skii i Proektno-Tekhnologicheskii Institut Zhivotnovodstva.*(2): 31-36.

Literature Rejection Categories		
Rejection Criteria	**Description**	**Receptor**
ABSTRACT (Abstract)	Abstracts of journal publications or conference presentations.	Wildlife Plants and Soil Invertebrates
ACUTE STUDIES (Acu)	Single oral dose or exposure duration of three days or less.	Wildlife
AIR POLLUTION (Air P)	Studies describing the results for air pollution studies.	Wildlife Plants and Soil Invertebrates
ALTERED RECEPTOR (Alt)	Studies that describe the effects of the contaminant on surgically-altered or chemically-modified receptors (e.g., right nephrectomy, left renal artery ligature, hormone implant, etc.).	Wildlife
AQUATIC STUDIES (Aquatic)	Studies that investigate toxicity in aquatic organisms.	Wildlife Plants and Soil Invertebrates
ANATOMICAL STUDIES (Anat)	Studies of anatomy. Instance where the contaminant is used in physical studies (e.g., silver nitrate staining for histology).	Wildlife
BACTERIA (Bact)	Studies on bacteria or susceptibility to bacterial infection.	Wildlife Plants and Soil Invertebrates
BIOACCUMULATION SURVEY (Bio Acc)	Studies reporting the measurement of the concentration of the contaminant in tissues.	Wildlife Plants and Soil Invertebrates
BIOLOGICAL PRODUCT (BioP)	Studies of biological toxicants, including venoms, fungal toxins, *Bacillus thuringiensis*, other plant, animal, or microbial extracts or toxins.	Wildlife Plants and Soil Invertebrates
BIOMARKER (Biom)	Studies reporting results for a biomarker having no reported association with an adverse effect and an exposure dose (or concentration).	Wildlife
CARCINOGENICITY STUDIES (Carcin)	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.	Wildlife Plants and Soil Invertebrates
CHEMICAL METHODS (Chem Meth)	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.	Wildlife Plants and Soil Invertebrates
CONFERENCE PROCEEDINGS (CP)	Studies reported in conference and symposium proceedings.	Wildlife Plants and Soil Invertebrates
DEAD (Dead)	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.	Wildlife Plants and Soil Invertebrates
DISSERTATIONS (Diss)	Dissertations are excluded. However, dissertations are flagged for possible future use.	Wildlife
DRUG (Drug)	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.	Wildlife Plants and Soil Invertebrates
DUPLICATE DATA (Dup)	Studies reporting results that are duplicated in a separate publication. The publication with the earlier year is used.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	**Description**	**Receptor**
ECOLOGICAL INTERACTIONS (Ecol)	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).	Wildlife Plants and Soil Invertebrates
EFFLUENT (Effl)	Studies reporting effects of effluent, sewage, or polluted runoff.	Wildlife Plants and Soil Invertebrates
ECOLOGICALLY RELEVANT ENDPOINT (ERE)	Studies reporting a result for endpoints considered as ecologically relevant but is not used for deriving Eco-SSLs (e.g., behavior, mortality).	Plants and Soil Invertebrates
CONTAMINANT FATE/METABOLISM (Fate)	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.	Wildlife Plants and Soil Invertebrates
FOREIGN LANGUAGE (FL)	Studies in languages other than English.	Wildlife Plants and Soil Invertebrates
FOOD STUDIES (Food)	Food science studies conducted to improve production of food for human consumption.	Wildlife
FUNGUS (Fungus)	Studies on fungus.	Wildlife Plants and Soil Invertebrates
GENE (Gene)	Studies of genotoxicity (chromosomal aberrations and mutagenicity).	Wildlife Plants and Soil Invertebrates
HUMAN HEALTH (HHE)	Studies with human subjects.	Wildlife Plants and Soil Invertebrates
IMMUNOLOGY (IMM)	Studies on the effects of contaminants on immunological endpoints.	Wildlife Plants and Soil Invertebrates
INVERTEBRATE (Invert)	Studies that investigate the effects of contaminants on terrestrial invertebrates are excluded.	Wildlife
IN VITRO (In Vit)	*In vitro* studies, including exposure of cell cultures, excised tissues and/or excised organs.	Wildlife Plants and Soil Invertebrates
LEAD SHOT (Lead shot)	Studies administering lead shot as the exposure form. These studies are labeled separately for possible later retrieval and review.	Wildlife
MEDIA (Media)	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.	Plants and Soil Invertebrates
METHODS (Meth)	Studies reporting methods or methods development without usable toxicity test results for specific endpoints.	Wildlife Plants and Soil Invertebrates
MINERAL REQUIREMENTS (Mineral)	Studies examining the minerals required for better production of animals for human consumption, unless there is potential for adverse effects.	Wildlife
MIXTURE (Mix)	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.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	**Description**	**Receptor**
MODELING (Model)	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.	Wildlife Plants and Soil Invertebrates
NO CONTAMINANT OF CONCERN (No COC)	Studies that do not examine the toxicity of Eco-SSL contaminants of concern.	Wildlife Plants and Soil Invertebrates
NO CONTROL (No Control)	Studies which lack a control or which have a control that is classified as invalid for derivation of TRVs.	Wildlife Plants and Soil Invertebrates
NO DATA (No Data)	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).	Wildlife Plants and Soil Invertebrates
NO DOSE or CONC (No Dose)	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.	Wildlife Plants and Soil Invertebrates
NO DURATION (No Dur)	Studies with no exposure duration. These are usually identified after examination of full paper.	Wildlife Plants and Soil Invertebrates
NO EFFECT (No Efct)	Studies with no relevant effect evaluated in a biological test species or data not reported for effect discussed.	Wildlife Plants and Soil Invertebrates
NO ORAL (No Oral)	Studies using non-oral routes of contaminant administration including intraperitoneal injection, other injection, inhalation, and dermal exposures.	Wildlife
NO ORGANISM (No Org) or NO SPECIES	Studies that do not examine or test a viable organism (also see in vitro rejection category).	Wildlife Plants and Soil Invertebrates
NOT AVAILABLE (Not Avail)	Papers that could not be located. Citation from electronic searches may be incorrect or the source is not readily available.	Wildlife Plants and Soil Invertebrates
NOT PRIMARY (Not Prim)	Papers that are not the original compilation and/or publication of the experimental data.	Wildlife Plants and Soil Invertebrates
NO TOXICANT (No Tox)	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.	Wildlife Plants and Soil Invertebrates
NO TOX DATA (No Tox Data)	Studies where toxicant used but no results reported that had a negative impact (plants and soil invertebrates).	Plants and Soil Invertebrates
NUTRIENT (Nutrient)	Nutrition studies reporting no concentration related negative impact.	Plants and Soil Invertebrates
NUTRIENT DEFICIENCY (Nut def)	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.	Wildlife
NUTRITION (Nut)	Studies examining the best or minimum level of a chemical in the diet for improvement of health or maintenance of animals in captivity.	Wildlife
OTHER AMBIENT CONDITIONS (OAC)	Studies which examine other ambient conditions: pH, salinity, DO, UV, radiation, etc.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	**Description**	**Receptor**
OIL (Oil)	Studies which examine the effects of oil and petroleum products.	Wildlife Plants and Soil Invertebrates
OM, pH (OM, pH)	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.	Plants and Soil Invertebrates
ORGANIC METAL (Org Met)	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.	Wildlife
LEAD BEHAVIOR OR HIGH DOSE MODELS (Pb Behav)	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.	Wildlife
PHYSIOLOGY STUDIES (Phys)	Physiology studies where adverse effects are not associated with exposure to contaminants of concern.	Wildlife
PLANT (Plant)	Studies of terrestrial plants are excluded.	Wildlife
PRIMATE (Prim)	Primate studies are excluded.	Wildlife
PUBL AS (Publ as)	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.	Wildlife Plants and Soil Invertebrates
QSAR (QSAR)	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.	Wildlife Plants and Soil Invertebrates
REGULATIONS (Reg)	Regulations and related publications that are not a primary source of data.	Wildlife Plants and Soil Invertebrates
REVIEW (Rev)	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.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	**Description**	**Receptor**
SEDIMENT CONC (Sed)	Studies in which the only exposure concentration/dose reported is for the level of a toxicant in sediment.	Wildlife Plants and Soil Invertebrates
SCORE (Score)	Papers in which all studies had data evaluation scores at or lower then the acceptable cut-off (#10 of 18) for plants and soil invertebrates).	Plants and Soil Invertebrates
SEDIMENT CONC (Sed)	Studies in which the only exposure concentration/dose reported is for the level of a toxicant in sediment.	Wildlife Plants and Soil Invertebrates
SLUDGE	Studies on the effects of ingestion of soils amended with sewage sludge.	Wildlife Plants and Soil Invertebrates
SOIL CONC (Soil)	Studies in which the only exposure concentration/dose reported is for the level of a toxicant in soil.	Wildlife
SPECIES	Studies in which the species of concern was not a terrestrial invertebrate or plant or mammal or bird.	Plants and Soil Invertebrates Wildlife
STRESSOR (QAC)	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.	Wildlife Plants and Soil Invertebrates
SURVEY (Surv)	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.	Wildlife Plants and Soil Invertebrates
REPTILE OR AMPHIBIAN (Herp)	Studies on reptiles and amphibians. These papers flagged for possible later review.	Wildlife Plants and Soil Invertebrates
UNRELATED (Unrel)	Studies that are unrelated to contaminant exposure and response and/or the receptor groups of interest.	Wildlife
WATER QUALITY STUDY (Wqual)	Studies of water quality.	Wildlife Plants and Soil Invertebrates
YEAST (Yeast)	Studies of yeast.	Wildlife Plants and Soil Invertebrates

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Appendix 5-1

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

March 2005

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Ref		Exposure															Effects					Conversion to mg/kg bw/day				Result		Data Evaluation Score										
Result #	Ref #	Chemical Form	MW%	Common Name	Phase #	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported	Body Weight (kg)	Ingestion Rate Reported?	Ingestion Rate (kg or L/day)	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Source	Dose Route	Test Concentrations	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total
Biochemical																																						
1	100	Cobalt chloride hexahydrate	24.90%	Chicken *(Gallus domesticus)*	1	4	0/10/100/500	mg/kg	U	FD	42	d	1	d	JV	B	CHM	RBCE	BL	100	500	N	1.6255	Y	0.038	0.920	4.59	10	10	5	10	6	1	8	10	10	4	74
2	6666	Cobalt	100%	Chicken *(Gallus domesticus)*	1	4	0/50/100/200	mg/kg	U	FD	3	w	1	d	JV	M	CHM	HMCT	BL	100	200	Y	0.2587	N	0.024	9.30	18.7	10	10	5	4	6	1	10	10	10	4	70
Behavior																																						
3	90	Cobalt chloride hexahydrate	100%	Chicken *(Gallus domesticus)*	1	4	0/116/251/472	mg/kg	M	FD	14	d	1	d	JV	M	FDB	FCNS	WO	116	251	Y	0.1238	Y	0.014	13.0	29.0	10	10	10	10	7	4	10	10	10	4	85
4	100	Cobalt chloride hexahydrate	24.9%	Chicken *(Gallus domesticus)*	2	2	0/500	mg/kg	U	FD	42	d	1	d	JV	B	FDB	FCNS	WO		500	Y	1.6255	Y	0.038		4.58	10	10	5	10	7	4	4	10	10	4	74
Pathology																																						
5	90	Cobalt chloride hexahydrate	100%	Chicken *(Gallus domesticus)*	1	4	0/116/251/472	mg/kg	M	FD	14	d	1	d	JV	M	HIS	GLSN	WO	116	251	Y	0.1238	Y	0.014	13.0	29.0	10	10	10	10	7	4	10	10	10	4	85
6	100	Cobalt chloride hexahydrate	24.90%	Chicken *(Gallus domesticus)*	2	2	0/500	mg/kg	U	FD	42	d	1	d	JV	B	ORW	ORWT	HE		500	Y	1.6255	Y	0.038		4.59	10	10	5	10	7	4	4	10	10	4	74
7	80	Cobalt chloride hexahydrate	100%	Duck *(Anas sp.)*	1	3	0/200	mg/kg	U	FD	15	d	1	d	JV	M	HIS	GLSN	MB		200	N	0.46	N	0.035		15.3	10	10	5	10	5	4	4	10	10	4	72
Growth																																						
8	397	Cobalt chloride	45.39%	Chicken *(Gallus domesticus)*	3	4	0/100/200/300	mg/kg	U	FD	5	w	1	d	JV	F	GRO	BDWT	WO	100	200	N	0.328	N	0.028	3.89	7.80	10	10	5	10	5	8	10	10	10	4	82
9	6666	Cobalt	100%	Chicken *(Gallus domesticus)*	1	4	0/50/100/200	mg/kg	U	FD	3	w	1	d	JV	M	GRO	BDWT	WO	50	100	Y	0.3738	N	0.030	4.10	8.20	10	10	5	4	6	8	10	10	10	4	77
10	92	Cobalt chloride hexahydrate	100%	Chicken *(Gallus domesticus)*	1	6	0/50/100/200/300/400	mg/kg	U	FD	2	w	1	d	JV	B	GRO	BDWT	WO	50	100	Y	0.328	N	0.00031	4.29	8.59	10	10	5	10	6	8	10	10	10	4	82
11	91	Cobalt chloride hexahydrate	100%	Duck *(Anas sp.)*	1	3	0/0.02/0.2	% in diet	U	FD	8	d	2	d	JV	NR	GRO	BDWT	WO	0.02	0.2	Y	0.5	Y	0.037	14.8	148	10	10	5	10	7	8	6	10	10	4	80
12	93	Cobalt carbonate	100%	Chicken *(Gallus domesticus)*	1	3	0/100/200	mg/kg	U	FD	2	w	1	d	JV	B	GRO	BDWT	WO	200		Y	0.109	N	0.014	25.2		10	10	5	10	6	8	4	1	10	4	68
13	1370	Cobolt chloride	100%	Chicken *(Gallus domesticus)*	1	2	0/200	mg/kg	U	FD	2	w	1	d	JV	B	GRO	BDWT	WO		200	N	0.328	N	0.028		17.0	10	10	5	10	5	8	4	10	10	4	76
14	90	Cobalt chloride hexahydrate	100%	Chicken *(Gallus domesticus)*	1	4	0/116/251/472	mg/kg	M	FD	14	d	1	d	JV	M	GRO	BDWT	WO		116	Y	0.2532	Y	0.027		12.0	10	10	10	10	7	8	4	10	10	4	83
15	6215	Cobalt chloride hexahydrate	100%	Chicken *(Gallus domesticus)*	1	2	0/250	mg/kg	U	FD	14	d	0	d	IM	M	GRO	BDWT	WO		250	N	0.328	N	0.028		21.5	10	10	5	10	5	8	4	10	10	4	76
16	81	Cobalt chloride heptahydrate	100%	Chicken *(Gallus domesticus)*	1	3	0/250/500	ug/g	U	FD	15	d	8	d	JV	M	GRO	BDWT	WO		250	Y	0.296	N	0.026		22.3	10	10	5	10	6	8	4	10	10	4	77
17	100	Cobalt chloride hexahydrate	24.9%	Chicken *(Gallus domesticus)*	2	2	0/500	mg/kg	U	FD	14	d	1	d	JV	B	GRO	BDWT	WO		500	Y	0.2532	Y	0.038		29.5	10	10	5	10	7	8	4	10	10	4	78
Survival																																						
18	100	Cobalt chloride hexahydrate	24.9%	Chicken *(Gallus domesticus)*	2	2	0/500	mg/kg	U	FD	42	d	1	d	JV	B	MOR	MORT	WO	500		Y	1.6255	Y	0.059	4.59		10	10	5	10	7	9	4	10	10	4	79
19	92	Cobalt chloride hexahydrate	100%	Chicken *(Gallus domesticus)*	1	6	0/50/100/200/300/400	mg/kg	U	FD	5	w	1	d	JV	B	MOR	MORT	WO	100	200	N	1.042	N	0.060	5.74	11.5	10	10	5	10	5	9	10	10	10	4	83
20	90	Cobalt chloride hexahydrate	100%	Chicken *(Gallus domesticus)*	1	4	0/116/251/472	mg/kg	M	FD	14	d	1	d	JV	M	MOR	MORT	WO	116	251	Y	0.2532	Y	0.027	12.3	26.7	10	10	10	10	7	9	10	10	10	4	90
21	1370	Cobolt chloride	100%	Chicken *(Gallus domesticus)*	1	2	0/200	mg/kg	U	FD	2	w	1	d	JV	B	MOR	MORT	WO	200		N	0.328	N	0.028	17.0		10	10	5	10	5	9	4	10	10	4	77
22	80	Cobalt chloride hexahydrate	100%	Duck *(Anas sp.)*	1	3	0/200	mg/kg	U	FD	15	d	1	d	JV	M	MOR	MORT	WO	200		N	0.46	N	0.035	15.0		10	10	5	10	5	9	4	10	10	4	77
23	6666	Cobalt	100%	Chicken *(Gallus domesticus)*	1	4	0/50/100/200	mg/kg	U	FD	3	w	1	d	JV	M	MOR	SURV	WO	200		Y	0.1662	N	0.018	22.0		10	10	5	4	6	9	4	10	10	4	72
24	80	Cobalt chloride hexahydrate	100%	Duck *(Anas sp.)*	2	2	0/200	mg/kg	U	FD	28	d	1	d	JV	M	MOR	MORT	WO		500	N	0.46	N	0.035		38.0	10	10	5	10	5	9	4	10	10	4	77

The abbreviations and definitions used in coding data are provided in Attachment 4-3 of the Eco-SSL Guidance (U.S.EPA, 2003).

Appendix 6-1

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

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March 2005

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Ref		Exposure															Effects					onversion to mg/kg bw/day Do				Result		Data Evaluation Score										
Result #	Ref #	Chemical Form	MW%	Test Organism	Phase #	# of Conc/ Doses	Conc or Doses	Conc or Dose Units	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight (kg)	Ingestion Rate Reported?	Ingestion Rate (kg or Lday)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	Data Source	Dose Route	Test Substrate	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total Score
Biochemical																																						
1	171	Cobalt nitrate	100	Cow (*Bos taurus*)	1	2	0/0.3	mg/kg bw/d	M	FD	45	d	7	mo	JV	F	CHM	HMGL	BL	0.3		Y	99	N	3.00	0.300		10	10	10	10	10	1	4	1	10	4	70
2	116	Cobaltous chloride	100	Rat (*Rattus norvegicus*)	1	6	0/10/50/100/200/300	ppm in mg/kg	U	FD	4	w	NR	NR	NR	B	CHM	HMGL	BL	200	300	Y	0.15	N	0.014	19.3	28.9	10	10	5	10	5	1	10	10	10	4	75
3	19290	Cobalt nitrate	100	Rat (*R. norvegicus*)	1	2	0/20	mg/kg bw/d	U	DR	30	d	NR	NR	JV	M	ENZ	P450	LI		20	Y	0.175	N	0.020		20.0	10	5	5	10	10	1	4	10	10	4	69
4	129	Cobalt chloride	100	Rat (*R. norvegicus*)	1	2	1	mg/ml	U	DR	35	d	NR	NR	JV	M	CHM	HMCT	BL		1	Y	0.1697	N	0.020		118	10	5	5	10	6	1	4	10	10	4	65
Behavior																																						
5	136	Cobalt chloride hexahydrate	24.9	Rat (*R. norvegicus*)	1	2	0/75	ppm in mg/kg	U	FD	80	d	44	d	JV	M	BEH	NMVM	WO	75		Y	0.47	N	0.037	1.47		10	10	5	10	6	4	4	3	10	4	66
6	86	Cobalt chloride hexahydrate	100	Pig (*Sus scrofa*)	2	4	0/200/400/600	mg/kg	U	FD	28	d	NR	NR	NR	NR	FDB	FCNS	WO		200	Y	41.58	N	1.47		7.08	10	10	5	10	6	4	4	10	6	4	69
7	111	Cobalt chloride	100	Rat (*R. norvegicus*)	1	2	0/20	mg/kg bw/d	M	DR	57	d	80	d	JV	M	BEH	ACTP	WO		20	Y	0.347	Y	0.035		20.0	10	5	10	10	10	4	4	10	10	4	77
Physiology																																						
8	105	Cobalt sulfate heptahydrate	21.91	Rat (*R. norvegicus*)	1	2	0/40	mg/kg bw/d	U	FD	16	w	NR	NR	NR	M	PHY	Other	HE		40	Y	0.387	N	0.031		8.76	10	10	5	10	10	4	4	10	10	4	77
Pathology																																						
9	136	Cobalt chloride hexahydrate	24.9	Rat (*R. norvegicus*)	1	2	0/75	ppm in mg/kg	U	FD	80	d	44	d	JV	M	HIS	GHIS	NR	75		Y	0.47	N	0.037	1.47		10	10	5	10	6	4	4	10	10	4	73
10	116	Cobaltous chloride	100	Rat (*R. norvegicus*)	1	6	0/10/50/100/200/300	ppm in mg/kg	U	FD	4	w	NR	NR	NR	B	ORW	SMIX	TS	50	100	Y	0.15	N	0.014	4.81	9.63	10	10	5	10	5	4	10	10	10	4	78
11	105	Cobalt sulfate heptahydrate	21.91	Rat (*R. norvegicus*)	1	2	0/40	mg/kg bw/d	U	FD	16	w	NR	NR	NR	M	GRS	BDWT	WO		40	Y	0.387	N	0.031		8.76	10	10	5	10	10	4	4	10	10	4	77
12	149	Cobalt chloride	100	Pig (*S. scrofa*)	1	2	0/500	ppm in mg/kg	U	FD	10	w	NR	NR	JV	M	HIS	GLSN	HE		500	Y	25.8	N	0.99		19.3	10	10	5	10	6	4	4	10	10	4	73
13	113	Cobalt chloride	45.39	Mouse (*Mus musculus*)	1	2	0/180	mg/kg bw/d	U	GV	5	d	NR	NR	GE	F	GRS	BDWT	WO		180	N	0.036	N	0.0045		81.7	10	8	5	10	10	4	4	10	10	4	75
14	129	Cobalt chloride	100	Rat (*R. norvegicus*)	1	2	1	mg/ml	U	DR	35	d	NR	NR	JV	M	ORW	SMIX	HE		1	N	0.1697	N	0.020		118	10	5	5	10	5	4	4	10	10	4	67
Reproduction																																						
15	126	Cobalt chloride	100	Rat (*R. norvegicus*)	1	3	0/5/20	mg/kg bw/d	U	FD	69	d	80	d	MA	M	REP	TEWT	TE	5	20	N	0.00021	N	0.000065	5.00	20.0	10	10	5	10	10	10	8	10	6	4	83
16	124	Cobalt chloride	45.39	Rat (*R. norvegicus*)	1	4	0/12/24/48	mg/kg bw/d	U	GV	28	d	NR	NR	MA	F	REP	PRWT	WO	12	24	Y	0.3	N	0.026	5.45	10.9	10	8	5	10	10	10	10	10	10	4	87
17	109	Cobalt chloride hexahydrate	24.9	Rat (*R. norvegicus*)	1	4	0/25/50/100	mg/kg bw/d	U	GV	9	d	NR	NR	GE	F	REP	PRWT	WO	100		Y	0.28	N	0.024	24.9		10	8	5	10	10	10	4	10	10	4	81
18	113	Cobalt chloride	45.39	Mouse (*M. musculus*)	1	2	0/180	mg/kg bw/d	U	GV	5	d	NR	NR	GE	F	REP	PROG	WO	180		Y	0.036	N	0.0045	81.7		10	8	5	10	10	10	4	1	10	4	72
19	121	Cobalt chloride hexahydrate	45.39	Mouse (*M. musculus*)	1	4	0/23/42/72	mg/kg bw/d	U	DR	13	w	12	w	SM	M	REP	RSUC	WO		23	Y	0.0375	N	0.0052		10.0	10	5	5	10	10	10	4	10	10	4	78
20	120	Cobalt chloride hexahydrate	24.9	Mouse (*M. musculus*)	1	2	0/400	mg/l	U	DR	9	w	12	w	MA	M	REP	TEWT	TE		400	N	0.037	N	0.0051		13.7	10	5	5	10	5	10	4	10	10	4	73
21	123	Cobalt chloride hexahydrate	100	Rat (*R. norvegicus*)	1	2	0/20	mg/kg bw/d	U	FD	70	d	100	d	SM	M	REP	TEDG	TE		20	N	0.523	N	0.040		20.0	10	10	5	10	10	4	4	10	10	4	77
22	119	Cobalt	100	Rat (*R. norvegicus*)	1	2	0/265	ppm in mg/kg	U	FD	98	d	100	d	MA	M	REP	TEWT	TE		265	Y	0.2	N	0.018		24.2	10	10	5	4	6	10	4	10	10	4	73
23	139	Cobalt chloride hexahydrate	100	Mouse (*M. musculus*)	1	2	0/43.4	mg/kg bw/d	U	DR	13	w	12	w	MA	M	REP	TEWT	TE		43.4	Y	0.045	N	0.0061		43.4	10	5	5	10	10	10	4	10	10	4	78
24	187	Cobalt chloride hexahydrate	100	Mouse (*M. musculus*)	1	2	0/400	mg/l	U	DR	10	w	8 to 10	w	JV	M	REP	PRFM	WO		400	N	0.0316	N	0.0044		55.9	10	5	5	10	5	10	4	10	10	4	73
Growth																																						
25	171	Cobalt nitrate	100	Cow (*Bos taurus*)	1	2	0/0.3	mg/kg bw/d	M	FD	45	d	7	mo	JV	F	GRO	BDWT	WO	0.3		Y	99	N	3.00	0.300		10	10	10	10	10	8	4	1	10	4	77
26	136	Cobalt chloride hexahydrate	24.9	Rat (*R. norvegicus*)	1	2	0/75	ppm in mg/kg	U	FD	80	d	44	d	JV	M	GRO	BDWT	WO	75		Y	0.47	N	0.037	1.47		10	10	5	10	6	8	4	1	10	4	68
27	86	Cobalt chloride hexahydrate	100	Pig (*S. scrofa*)	1	4	0/25/50/100	mg/kg	U	FD	16	w	NR	NR	NR	NR	GRO	BDWT	WO	100		Y	97.5	Y	2.35	2.41		10	10	5	10	7	8	4	10	6	4	74
28	121	Cobalt chloride hexahydrate	45.39	Mouse (*M. musculus*)	1	4	0/23/42/72	mg/kg bw/d	U	DR	5	w	12	w	SM	M	GRO	BDWT	WO	42	72	Y	0.0375	Y	0.0078	19.0	33.0	10	5	5	10	10	8	10	10	10	4	82
29	132	Cobalt sulfate	100	Guinea pig (*Cavia porcellus*)	1	2	0/20	mg/kg bw/d	U	OR	5	w	NR	NR	MA	M	GRO	BDWT	WO	20		Y	0.478	N	0.037	20.0		10	8	5	10	10	8	4	10	3	4	72
30	111	Cobalt chloride	100	Rat (*R. norvegicus*)	1	2	0/20	mg/kg bw/d	M	DR	57	d	80	d	JV	M	GRO	BDWT	WO	20		Y	0.347	Y	0.035	20.0		10	5	10	10	10	8	4	1	10	4	72
31	116	Cobaltous chloride	100	Rat (*R. norvegicus*)	1	6	0/10/50/100/200/300	ppm in mg/kg	U	FD	4	w	NR	NR	NR	B	GRO	BDWT	WO		10	Y	0.15	N	0.014		0.963	10	10	5	10	6	8	4	10	10	4	77
32	109	Cobalt chloride hexahydrate	24.9	Rat (*R. norvegicus*)	1	4	0/25/50/100	mg/kg bw/d	U	GV	9	d	NR	NR	GE	F	GRO	BDWT	WO		25	Y	0.28	N	0.024		6.23	10	8	5	10	10	8	4	10	10	4	79
33	149	Cobalt chloride	100	Pig (*Sus scrofa*)	1	2	0/500	ppm in mg/kg	U	FD	5	w	NR	NR	JV	M	GRO	BDWT	WO		500	Y	19.8	N	0.80		20.2	10	10	5	10	6	8	4	10	10	4	77
34	139	Cobaltous chloride hexahydrate	100	Mouse (*M. musculus*)	1	2	0/43.4	mg/kg bw/d	U	DR	13	w	12	w	MA	M	GRO	BDWT	WO		43.4	Y	0.045	N	0.0061		43.4	10	5	5	10	10	8	4	10	10	4	76
35	129	Cobalt chloride	100	Rat (*R. norvegicus*)	1	2	1	mg/ml	U	DR	24	d	NR	NR	JV	M	GRO	BDWT	WO		1	Y	0.1262	N	0.015		122	10	5	5	10	6	8	4	10	10	4	72
Survival																																						
36	149	Cobalt chloride	100	Pig (*S. scrofa*)	1	2	0/500	ppm in mg/kg	U	FD	10	w	NR	NR	JV	M	MOR	MORT	NR	500		Y	25.8	N	0.99	19.3		10	10	5	10	6	9	4	10	10	4	78
37	113	Cobalt chloride	45.39	Mouse (*M. musculus*)	1	2	0/180	mg/kg bw/d	U	GV	5	d	NR	NR	GE	F	MOR	MORT	NR	180		Y	0.036	N	0.0045	81.7		10	8	5	10	10	9	4	10	10	4	80
38	132	Cobalt sulfate	100	Guinea pig (*Cavia porcellus*)	1	2	0/20	mg/kg bw/d	U	OR	5	w	NR	NR	MA	M	MOR	SURV	WO		20	Y	0.478	N	0.037		20.0	10	8	5	10	10	9	4	10	3	4	73
Data Not Used to Derive TRV																																						
39	86	Cobalt chloride hexahydrate	100	Pig (*S. scrofa*)	1	4	0/25/50/100	mg/kg	U	FD	16	w	NR	NR	NR	M	CHM	HMGL	BL	100		Y	97.5	Y	2.35	2.40		10	10	5	10	7	1	4	3	6	4	60
40	149	Cobalt chloride	100	Pig (*S. scrofa*)	1	2	0/500	ppm in mg/kg	U	FD	10	w	NR	NR	JV	M	ENZ	GLPX	BL	500		Y	25.8	N	0.99	19.3		10	10	5	10	6	1	4	3	10	4	63
41	121	Cobalt chloride hexahydrate	45.39	Mouse (*M. musculus*)	1	4	0/23/42/72	mg/kg bw/d	U	DR	12	w	12	w	SM	M	CHM	HMCT	BL	72		Y	0.038	Y	0.0064	30.6		10	5	5	10	7	1	4	1	10	4	60
42	86	Cobalt chloride hexahydrate	100	Pig (*S. scrofa*)	3	2	0/400	mg/kg	U	FD	2	w	NR	NR	NR	NR	CHM	HMGL	BL		400	Y	23.62	Y	0.97		16.4	10	10	5	10	7	1	4	10	3	4	64

The abbreviations and definitions used in coding data are provided in Attachment 4-3 of the Eco-SSL Guidance (U.S.EPA, 2003).