

# Selenium Research Update

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## I. Selenium in the Environment

A. "Biogeochemistry and Analysis of Selenium and its Species". Prepared for North American Metals Council, Washington, DC, by University of North Dakota, University of Kentucky, and Trent University, December 2008.

[BiogeochemistryandAnalysisofSeleniumanditsSpecies2008.pdf](#)

The guide summarizes selenium chemistry, distribution, geochemistry, physiology and toxicology to aid in identifying analytically important chemical forms of selenium in environmental and biological samples. This guide focuses on appropriate analytical methods for performing reliable analyses of selenium in environmental media such as ores, soils, sediments, and water as well as biological tissues. The relationship between environmental selenium concentrations and the amounts of selenium bioaccumulate from the environment are essential components of site specific assessments of potential risks related to selenium exposures. The determination of selenium and its species at ambient concentrations is complicated and inappropriate analytical procedures have frequently been used. Selecting the best analytical approaches will obtain the most reliable data regarding selenium's concentration dependent effects in supporting normal physiology or potentially inducing toxicity. Analyses of total selenium and selenium speciation should be used in a complementary and comparative manner for risk assessment and remediation strategies.

B. "Mineral Status, Toxic Metal Exposure and Children's Behavior", *The Journal of Orthomolecular Medicine*, Volume 16, First Quarter 2001.

[www.orthomolecular.org/librarn/jom/2001](http://www.orthomolecular.org/librarn/jom/2001)

This study investigated the relationship between hair element status and problem behavior in 237 children in elementary schools in Victoria, British Columbia. Previous research in Canada suggests that approximately one in five children suffer from one or more psychological disorders which may impair day- to-day functioning. The basis of behavioral status was the Walker Problem Behavior Identification Checklist. The elements assessed included the toxic metals aluminum, arsenic, cadmium, lead and mercury and the essential minerals calcium chromium, copper, magnesium, manganese, selenium and zinc. While the body stores a wide range of toxic and essential elements in tissues including the blood, urine, teeth and organ samples, scalp hair is increasingly considered a more desirable biopsy material. As an excretory tissue, hair incorporates elements during growth providing a long duration record of elements versus the short term variability in blood and urine concentrations of elements. With respect to specific behavioral problems, "distractibility" may be the most affected by mineral status, with significant associations observed between this problem behavior and "low" calcium, "high manganese, and "high" cadmium in hair samples. Low hair levels of the macro-mineral calcium, in particular, appear to be a significant factor in behavioral problems. Normal reference ranges for hair analysis for twelve elements are presented in Table 1 below.

**Table 1. Normal Reference Ranges for Hair Analysis (Doctor's Data, Inc. St Charles, Illinois)**

<b>TOXIC ELEMENTS</b>	<b>Males 6+ Years (ppm)</b>	<b>Females 6+ Years (ppm)</b>
Aluminum	≤8.00	≤9.00
Arsenic	<0.15	<0.15
Cadmium	<0.25	<0.25

Lead	<0.70	<0.70
Mercury	<1.50	<1.50
<b>BULK ELEMENTS</b>		
Calcium	160-480	300-760
Magnesium	12-44	35-70
<b>TRACE ELEMENTS</b>		
Chromium	0.35-0.80	0.35-0.80
Copper	9-20	12-33
Manganese	0.30-0.50	0.30-0.60
Selenium	0.95-1.70	0.95-1.70
Zinc	110-140	115-155

The elemental status, functional characteristics, toxicity, and sources of the elements are discussed and referenced. For example, aluminum may be consumed from many products such as pickles, antacids, aluminum cans, cookware or foil, drinking water and skin contact with antiperspirant use. However, for those with normal renal function, aluminum is usually removed by the kidney provided that adequate systemic levels of magnesium, calcium, zinc and phosphorus are available.

A high level in zinc in scalp hair may be indicative of low zinc in cells and a functional zinc deficiency. Zinc can be readily displaced from the intracellular zinc binding protein by elevated levels of other metals such as cadmium, lead, copper, and mercury, resulting in “wasting” of zinc and consequently an increased accumulation of the element in the hair. Therefore, in children for whom industrial exposures to zinc are improbable, high levels of zinc in the hair a probably indicative of low meat diets, the consumption of refined foods, and high fat and sugar intake.

Possible sources of cadmium exposures include second-hand cigarette smoke dental amalgams which are also a source of mercury exposures. A geographical association between selenium deficiency and schizophrenia has been suggested, while toxic levels of this micronutrient have been linked to irritability. Significant direct correlations between hair selenium levels and teacher’s responses to the Walker Problem Behavior Identification Checklist have been reported for school-aged children.

C. “Selenium: Mercury’s Magnet”.

[www.mercuryfacts.org/fseleniumcfm](http://www.mercuryfacts.org/fseleniumcfm)

Fish concentrations of mercury must be associated with concentrations of selenium, as selenium has a high binding affinity for mercury which means that these two substances combine to form a new substance. When mercury binds to selenium, it is no longer free to bind to anything else, like brain tissues. Researchers at the National Oceanic and Atmospheric Administration and North Dakota researcher (Dr. Ralston) concluded that most of the fish we eat contains significantly more selenium than mercury so we are protected from the negative effects of mercury due to the selenium present. The seafood that contains more mercury than selenium includes pilot whale, tarpon, marlin, and some shark. Fish, we most commonly consume, including all forms of tuna and salmon, are rich in selenium.

D. “Mercury-Selenium Compounds and Their Toxicological Significance: Toward a Molecular Understanding of the Mercury-Selenium Antagonism”, *Environmental Toxicology and Chemistry*, in press, April 2009.

[www.setacjournals.org](http://www.setacjournals.org)

The interaction between mercury and selenium is one of the best known examples of biological antagonism, yet the underlying mechanism remains unclear. This review focuses on the potential Hg-Se compounds that are responsible for the antagonism at the molecular level (i.e., bis(methylmercuric) selenide, methylmercury selenocysteinate, selenoprotein P-bound HgSe clusters, and the biominerals). The presence of these compounds in biological systems has been suggested by direct or indirect evidence, and the chemical properties support their potentially key roles in alleviating the toxicity of mercury and selenium at high exposures and the deficiency of selenium at low exposures. Direct analytical evidences are needed to confirm their in vivo presence and metabolic pathways.

## **II. Aquatic Toxicology Resources**

A. "Ecological Assessment of Selenium in the Aquatic Environment: Summary of a SETAC Pellston Workshop". Sponsored by the Society of Toxicology and Chemistry (SETAC), April 2009.

[www.setac.org/node/265](http://www.setac.org/node/265)

This SETAC Pellston Workshop brought 46 key individuals from industry, academia and the government to develop a consensus for the assessment of selenium in the aquatic environment. Key findings in diagnosing the adverse effects of selenium included:

1. Selenium is a growing problem of global concern.
2. Diet is the primary pathway of selenium exposure for both invertebrates and vertebrates.
3. Traditional methods for prediction toxicity on the basis of exposure to dissolved concentrations do not work for selenium because the behavior and toxicity of selenium in aquatic systems are highly dependent upon site-specific factors, including food web structure and hydrology.
4. Selenium toxicity is primarily manifested as reproductive impairment due to maternal transfer, resulting in embryo toxicity and teratogenicity in egg-laying vertebrates.
5. A key aspect of selenium toxicity is the narrow range between dietary essentiality and toxicity.
6. Differences in species sensitivities to selenium may be related to differences in reproductive physiology, dynamics of selenium transfer from diet to body tissues to eggs, and/or differences in capacity to metabolize organic selenium to more reactive oxidized species.
7. Protection of the top predators may not guarantee protection of all biota lower in the food web.
8. Aquatic dependent mammals do not appear to be as sensitive as fish or birds to dietary organic selenium exposure.
9. The most sensitive toxicity endpoint in birds is embryo mortality.
10. The most sensitive endpoints in fish larvae are teratogenic deformities such as skeletal, craniofacial, and fin deformities, and various forms of edema.
11. Embryo mortality and severe development abnormalities can result in impaired recruitment of individuals into populations.
12. A single, universal, dissolved water quality value is inappropriate for predicting toxicity.
13. There is consensus that fish and bird eggs are the critical media for assessing selenium toxicity at a given location, and measured concentrations in these tissues are most strongly linked to adverse effects.
14. Selenium requires site-specific risk assessments, including adequate quality assurance and quality control of chemical and biological analyses, to a much greater extent than many other contaminants.

B. "Assessment of Larval Deformities and Selenium Accumulation in Northern Pike and White Sucker Exposed to Metal Mining Effluent", *Environmental Toxicology and Chemistry*, Volume 28, Issue 3, March 2009.

[www.setacjournals.org](http://www.setacjournals.org)

Uranium mining and milling operations in Canada release effluents with elevated levels of certain trace metals and metalloids, including selenium. This study evaluated the presence of selenium induced deformities in northern pike and white sucker larvae originating from adults collected downstream of a uranium mine. Selenium concentrations in northern pike and white sucker eggs were about 8.0 and 5.0 ug/g dry weights, respectively. Among all evaluated deformities (skeletal curvatures, craniofacial deformities, fin deformities, and edema), only edema in white sucker fry from the exposure site was

slightly elevated. However, edema is associated with many other factors such as other metals and organic compounds. Both fish species displayed strong linear relationships between the selenium concentrations in eggs and other tissues (muscle, liver, kidney, and bone) suggesting that selenium concentrations in eggs could be predicted from selenium concentrations in adult tissues. The lack of a clear, toxic response in the present study is in agreement with selenium thresholds for early life-stage deformities reported in other studies, with egg selenium concentrations being less than the 10 ug/g (dry weight) threshold associated with the presence of deformities.

C. "Mercury Demethylation in Waterbird Livers: Dose-Response Thresholds and Differences among Species", *Environmental Toxicology and Chemistry*, Volume 28, Issue 3, March 2009.

[www.setacjournals.org](http://www.setacjournals.org)

Researchers assessed methylmercury (MeHg) demethylation in the livers of adults and chicks of four waterbird species that commonly breed in San Francisco Bay. Water birds demethylated mercury in their livers if exposure exceeds a threshold value of about 8.5 ug/g dry weight of total mercury in the liver. Selenium concentrations were positively correlated with inorganic mercury in the livers of birds above the demethylation threshold but not below. This suggests that selenium may act as a binding site for demethylated mercury and may reduce the potential for secondary toxicity.

D. "Assessment of the Ecological Effects of Arsenic on a Southern Ohio, USA Stream," *Integrated Environmental Assessment and Management*, Volume 5, Issue 2, April, 2009.

[www.setacjournals.org](http://www.setacjournals.org)

Davis Creek receives a permitted discharge from the Belpre Elastomers Plant (BEP). A two year study of surface water, sediment quality, and aquatic toxicity tests was conducted. The concentration of arsenic in surface and interstitial water was below USEPA ambient water quality criteria, was not toxic in invertebrates tested, despite sediments exceeding arsenic sediment screening values in nearly all samples collected. The sediment quality triad investigation indicated that Davis Creek was not significantly affected by arsenic associated with the plant discharge, despite having measured arsenic concentrations that exceeded sediment screening values. This research provides an example of monitored levels of a pollutant exceeding sediment screening values, but not having aquatic impacts according to USEPA toxicity testing procedures.

E. "Concentrations of Selenium and Mercury in Eared Grebes from Utah's Great Salt Lake, USA, in press, April 2009.

[www.setacjournals.org](http://www.setacjournals.org)

Selenium and mercury liver concentrations were measured in eared grebes in the fall of 2006 from the Great Salt Lake, Utah. Their diet consisted mainly of brine shrimp. The liver selenium concentrations were higher in November (14.5 ug/g) than September (9.4 ug/g), and mercury concentrations were also higher in November (8.4 ug/g) than September (5.6 ug/g). Selenium and mercury blood and liver levels were correlated. Body, liver, and spleen mass relationships were not correlated or the relationship was positive with increasing selenium and mercury concentrations. The results suggest that high mercury and selenium levels were not preventing grebes for increasing or maintaining mass.

F. "Database of Selenium Concentrations in Fish Tissues from Reference Sites". Prepared for North American Metals Council, Washington, DC, by Parametrix, Bellevue, WA, January 8, 2009.

[SeTissueThresholdReportFinal1-19-09.zip](#)

The objective of the selenium database compilation is to identify fish selenium concentrations (whole body tissue, muscle, ovaries and eggs) associated with reference sites that are not impacted, or minimally impacted by anthropogenic activities that could result in the mobilization of selenium into water bodies. The comprehensive database survey included numerous government and industrial sources of information in the USA and Canada. Cumulative database selenium concentrations in fish tissues and recommended guidelines are presented in Table 1.

Table 1. Database of Selenium Concentrations in Fish Tissues from Reference Sites and Recommended Guidelines.

<b>FISH TISSUE</b>	<b>Cumulative Data Synthesis of Selenium Concentrations (90<sup>th</sup> %) ug/gram dry weight</b>	<b>Recommended Draft USEPA Criterion, 2009 ug/gram dry weight</b>	<b>Recommended Guideline DeForest, 1999 ug/gram dry weight</b>
Whole Body	6.8	7.91	9.0
Muscle	4.8		
Eggs	15.2		17.0
Ovaries	24.0		17.0

G. "Approach for Conducting Site-specific Assessments of Selenium Bioaccumulation in Aquatic Systems". Prepared for North American Metals Council, Washington, DC, by CH2M HILL and NewFields, December 2008.

[SeTissueThresholdReportFinal1-19-09.zip](#)

The goal of the document is to provide a standard guide for field and laboratory assessments of selenium bioaccumulation that can be applied in different environmental settings relative to developing and interpreting a tissue-based selenium value. This guide provides a general summary of relevant information concerning tissue thresholds/guidelines and a general summary of appropriate analytical methods for doing reliable analyses of selenium in environmental media and tissues, which are an essential component of conducting site-specific assessments of selenium bioaccumulation. It may be assumed that current suggested draft selenium criteria are conservative and that site specific studies with a risk assessment approach will be needed to set protective site specific standards. Risk management and remediation decisions should be based on integration of biology and chemistry data. The tiered approach recommended for assessment of selenium in aquatic systems included:

1. Comparison of tissue concentrations to tissue residue guidelines or adopted water quality criteria.
2. Reproductive toxicity testing.
3. Assessment of fish populations in the area of interest.

H. "Selenium Tissue Thresholds: Tissue Selection Criteria, Threshold Development Endpoints, and Potential to Predict Population or Community Effects in the Field". Prepared for North American Metals Council, Washington, DC, by GEI, Golder, Parametrix and University of Saskatchewan, December 2008. [SeTissueThresholdReportFinal1-19-09.zip](#)

The Tissue Threshold Workgroup was charged with conducting a vigorous evaluation of the state of science with respect to selenium toxicity in fish and implications for developing a broadly applicable tissue-based criterion. Since the EPA drafted a whole-body fish selenium criterion of 7.91 ug/g dry weight in 2004, new selenium toxicity studies have been published. Questions addressed included:

- What is the appropriate tissue for deriving a fish selenium threshold?
- What is the appropriate endpoint, life stage, and effect level for deriving a fish selenium threshold?
- Are fish selenium thresholds predictive of population level effects?

Recommendations included:

1. The appropriate tissue and endpoint for developing a broadly applicable fish tissue selenium guideline or criterion is the egg selenium concentration (EC10 = 17 ug/g dry weight), as associated with the effects threshold for larval deformities and mortality resulting from the maternal transfer of selenium.
2. The concentration of selenium in one tissue should not be estimated from another tissue using regression relationships based on other species and studies. However, use of species-specific and site-specific tissue to tissue relationships may be reasonable for evaluation selenium compliance at a site.
3. More field based studies are necessary to understand the potential impacts of selenium on stream fish populations at concentrations above recommended criteria. Field studies are also necessary to evaluate the significance of winter stress syndrome, as to date this endpoint has been documented only in the laboratory. Additional field documentation of selenium effects in standing waters is needed to determine if effects from historic studies can be quantified at other sites.
4. Consistency in analyzing selenium and deformities in larval fish needs further work as well as consistency in reporting laboratory information such as the moisture content of fish tissues.

I. "A Call for Help To Evaluate the Risks of the TVA Ash Dredge Plan and To Prevent Loss of The Watts Bar Reservoir", Dr. Bryce F. Payne Jr., March 2009. [TVAspillashSebrief.zip](#)

On December 22, 2008 a sixty foot ash and earthen wall securing a retention pond at the Tennessee Valley Authority's (TVA) Kingston Fossil Plant holding five decades of coal fly ash gave way causing a catastrophic wave of ash and slurry to cover 300 acres of nearby land and water. Fortunately, there were no serious injuries, but the impacts on the land and water were severe. Posted on the website are two discussions of the potential environmental harm which may ensue due to the release of selenium compounds from the coal fly ash during the dredging operations proposed and enacted. The NPDES permit of the TVA (Tennessee Valley Authority Kingston plant expired in 2008, and none of its permits ever regulated arsenic or selenium, as is typical for coal fired power plants throughout the USA.

A 1998 investigation determined the total and water soluble selenium in 23 different coal fly ashes from power plants in the southeastern USA averaged 21.0 ppm total selenium and a water soluble selenium

concentration of 2.7 ppm. There likely values for selenium originally in the now spilled ash suggest that the average daily historical selenium load in the ash settling pond was about 6 pounds/day. This estimate raises the likely historical selenium, load into the Clinch and Emory Rivers and Watts Bar Reservoir due to discharge of the TVA Kingston ash settling pond effluent to 90,000 pounds.

The TVA Dredge Plan contains other data that need scrutiny. The Watts Bar Reservoir Aquatic life and fisheries may be destroyed, if planned dredging goes forward. Coal can be used as an essential and economical resource if used properly according to USEPA and all applicable federal regulations.

### III. Human Exposures to Selenium

**A. Recently, April 2009, Nebraska drinking water well supplies have been abandoned due to high selenium concentrations which exceeded the EPA MCL of 0.05 mg/L.**

[http://ww.pennnet.com/news/display\\_news\\_story.cfm?Section=WireNews](http://ww.pennnet.com/news/display_news_story.cfm?Section=WireNews)

Drinking well water supplies to the town of Albion, Nebraska were abandoned April 5, 2009 due to high concentrations of selenium which exceeded the EPA MCL (Maximum Concentration Limit) for the drinking water standard of 0.05 mg/L selenium. The maximum concentrations were about 0.25 mg/L. If one consumes two liters of community water per day at 0.25 mg/L, the amount of selenium ingested is about a third of the total recommended maximum daily intake allowance for selenium (1.5 mg Se/day).

### **B. Dietary Assessment of Selenium**

If one consumes one serving (four ounces) of ham or turkey or half ounce of Brazil nuts, the daily recommended allowance (RDA=0.4 mg/day , USDA, 1974) for total selenium intake has been met, as represented in the table below.

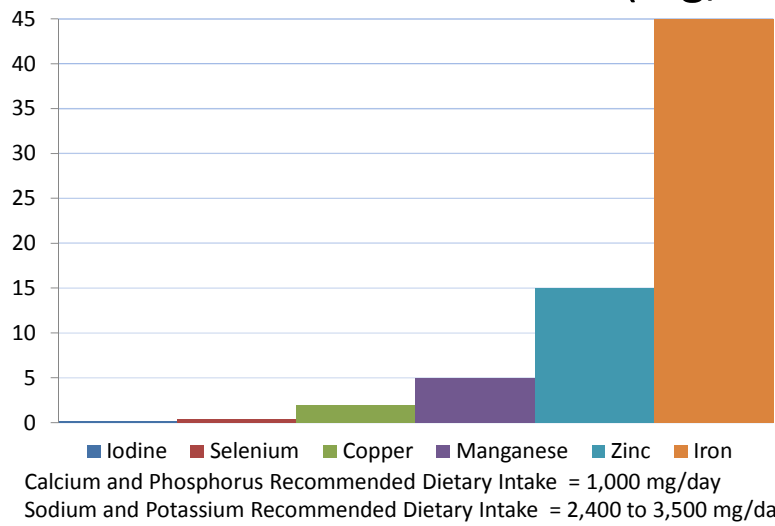
## Dietary Intake of Selenium in Representative Food Sources

FOOD SOURCE	DIETARY AMOUNT	DAILY INTAKE OF SELENIUM	PERCENT of RDA
<b>MAXIMUM SAFE LEVEL</b>		<b>~0. 4 mg/day Se</b>	<b>100%</b>
1. Brazil Nuts	1 ounce	0.80 mg	200%
2. Ham or Turkey	4 ounces	0.40 mg	100%
3. Tuna or Flounder	4 ounces	0.08 mg	20%
4. Chicken	4 ounces	0.04 mg	10%
5. Eggs	2 eggs	0.03 mg	8.0%
6. Brown Rice or Oatmeal	1 cup	0.02 mg	5.0%
7. Multiple Vitamin Supplement	1 tablet	0.02 mg	5.0%
<b><u>TOTAL DAILY INTAKE</u></b> <b><u>(7 Food Sources)</u></b>			<b><u>348%</u></b>

6

The recommended daily intake (RDA) of selenium required in the diet is minimal compared to other essential elements as illustrated below. Therefore, dietary and supplemental intake of selenium must be closely monitored.

## Relative Adult Recommended Dietary Intakes of Selected Minerals (mg/day)



5

## **IV. Livestock Feeds & Selenosis**

### **A. Selenium in Animal Feeds**

1. "Final Environmental Impact Statement, Rule Making on Selenium in Animal Feeds", Bureau of Veterinary Medicine, Food and Drug Administration, Department of Health, Education and Welfare, FEDERAL REGISTER of April 27, 1973 (38 FR 10458).

In reference to the control of selenium usage, it should be recognized that all feed additives are subject to Section 409 of the Federal Food, Drug, and Cosmetic Act. Twenty seven comments from various sources were received and comments were summarized. The judicious monitoring of the proposed use of selenium was emphasized in several comments. It was unclear as to why all animals and birds in all geographical locations must or should be treated alike and as to how the use of selenium could be confined to proven incidences of deficiency demonstrated and defined by known clinical symptoms. Since at least 30% of the populations of animals and birds are already receiving a selenium adequate diet, not all populations need to be reared on selenium supplemented feeds. In most animals, 3.0 ppm of dietary selenium approximates the minimum toxic dose. Further, the capability of the FDA to provide the manpower necessary to monitor the proposed use of selenium was questioned.

Provisions to be monitored included:

1. An upper limit on the concentration of selenium in premixes and will require the use of highly diluted premixes.
2. Each production batch of selenium premix is to be analyzed for selenium content. This analysis will assure that selenium premixes contain the labeled amount of selenium and, in no case will this amount exceed 90.8 mg of selenium per pound.
3. The application of a caution statement to the label as specified will ensure that feeds prepared from the selenium premixes will be manufactured according to label directions.

2. "Selenium Rich Wheat", South Dakota Wheat Commission, Supplement to the *Dakota Farmer*, February 2007.

<http://magissues.farmprogress.com/DFM/DK02Feb07/dfm101.pdf>

Dr. Combs from the Grand Forks Human Nutrition Research Center in North Dakota explains the nutritional essentiality of selenium as an antioxidant helping to control cell damage that can lead to cancer. One objective for the ongoing research is to establish a market for wheat products naturally rich in selenium. The researchers are analyzing the soil selenium content and distribution data along with the wheat grain selenium content, partnered with seasonal rainfall data. The majority of the US has soils that are very low in selenium, requiring the supplementation of animal feeds to prevent deficiency related diseases. There are soils from the Niobrara marls and Pierre Shale which outcrop along the western edge of the Missouri River that are exceptionally high in selenium. These pockets of soil produce plant and animal products that are richer in selenium than those produced in other areas. The same area is well suited to growing wheat, which is thought to be the most efficient of the common cereal crops in accumulating selenium.

### **B. Swine Selenosis**

1. "Report to National Pork Board", by Dr. Don Mahan, Ohio State University, 2008.

A 2008 report to the National Pork Board explains the occurrence of selenium toxicity in the pork industry in the Western USA for the past few years. Producers have struggled with animal health, reproductive and lameness issues that do not seem to respond to conventional treatments, should discuss the possibility of selenium toxicity with the herd veterinarian. Producers also should enlist the assistance of a qualified nutritionist to ensure that rations are adequate but not high in selenium, and balanced for all other nutrients. The report explains the symptoms of selenium toxicity, the difference between acute and chronic toxicity, potential dietary sources, and other advice for livestock producers. (ATTACH PDF 2008 Report National Pork Board, Don Mahan, 6 pages)

2. "Swine Toxicity & Selenium in Grains", by Karen Hagelstein, TIMES Limited, Sheridan, WY, April 2009. The technical report (20 pages) addresses the USA experiences with selenium as a micronutrient and poison, a recent case study of swine selenosis, and research about the selenium content and distribution in forage and grain. A legal case and jury trial involving swine herd deaths in Oregon due to selenosis is in progress. The swine producer lost sows and piglets due to high concentrations of selenium in the feed mixtures which were prepared according to label instructions. (ATTACH PDF Swine Toxicity & Se in Grains, April 2009, 20 pages)  
(ATTACH PPT Case Study Swine Selenosis, April 2008, 11 slides)

3. "Swine Diets", Fact Sheet Pork Information Gateway, PIG 07-01-04.

Since the 1980's swine production has undergone tremendous changes related primarily to increasing size, specialization, and efficiency of individual production units. However, one factor has remained constant which is production cost attributed to feed costs (55-65%). This publication provides examples of properly formulated swine diets for various classes of swine.

### **C. Equine Selenosis**

<http://msn.foxsports.com/other/story/9480120/Polo-player-says-supplement-killed-21-polo-horses#tb>

On April 19, 2009, polo ponies (21) in Wellington, Florida competing at the International Polo Club were injected with a vitamin supplement to enhance their energy level and performance. A compounded supplement, containing Vitamin B12 and excessive sodium selenite may have killed the horses, who died about three hours after the injection. The necropsies indicated internal bleeding, but other information has not been provided. One suggested source of the supplement was "Biodyl".

"Biodyl", Injectable Solution (100 ml) with Vitamin B12 and sodium selenite (0.05 grams and 0.1 grams respectively) is used for the treatment of muscle disorders in all species. Warning: do not administer more than 3 or 4 successive injections separated by 24 or 48 hour intervals, for veterinary use. Material Safety Data Sheet for Merial SAS, 29, avenue Tony GARNIER F-69 007 Lyon, France.

### **D. Historical Selenium Warnings**

1. The following research article and discussion (nearly verbatim) were published over 60 years ago. Yet, case studies of selenium poisoning in livestock are still reported in the USA in 2009. The symptoms of

selenosis in livestock have not changed, but public and producer awareness of the symptoms of selenosis apparently needs upgrading.

“Selenium Poisoning of Livestock”, by L. W. Durrell and F. Cross, Colorado State College Extension Service, Fort Collins, CO, June 1944.

In 1931, a preliminary survey of alkali disease was made in Nebraska, South Dakota, and eastern Wyoming. The toxicity in the plants seemed to be correlated with soil from Pierre shale. Selenium was found in the plants and soils from these regions. Alkali disease in horses, cattle, and sheep is expressed by a depressed growth rate and loss of hair, especially the mane and tail in the case of horses. The hoofs develop abnormal and in severe poisoning, the hoofs slough off. In the more acute cases of selenium poisoning, the animals walk aimlessly, their vision is apparently impaired, as they walk into fences and other obstructions. The digestive system is believed to be inactive, the appetite is depraved, and the animals sometimes chew on fence rails, pieces of bone, or any metallic object. Finally, the animal grinds its teeth, drools from the mouth, and paralysis results. At the chronic stage of selenosis, horses and cattle have abnormal growth of the hoofs, with the formation of deep rings. There is considerable stiffness and emaciation of the animal. In poultry, selenium poisoning prevents about 75% of the eggs from hatching. The hatched chicks are greasy looking, often abnormal, and frequently live only a few hours.

Autopsies of poisoned animals reveal lesions of the liver and erosions are found in the articular surfaces. The conditions described may prevail for several months, or even years, although the poisoned animals may recover when placed on good feed. Dr. Beath of the Wyoming describes a “delayed action” in which the animals may not show symptoms for several months while eating selenium plants, then suddenly a break down occurs and death follows in 1-5 days. Generally, two types of the disease are recognized, the “alkali disease” and the “blind Stagers”. It is now believed that these are the same disease and that the alkali disease is the less acute form, characterized by abnormal hoof growth, sloughing of the hoofs, and loss of hair. The blind stagers is the more acute form, which results in the death in a short time with no loss of hair or hoofs.

Numerous plants are able to absorb selenium from the soil and accumulate it in their tissues. Some plants growing in soil containing a few parts per million, may accumulate as much as 1000 to 1200 ppm. Plants grown experimentally in soil high in selenium turn white, however, in nature, the plants remain green. The odor of these plants is distinctive, however. If an indicator plant, such as milk vetch, is crushed in the hand, a peculiar sulfurous odor is noticeable if the plant contains selenium. In the plant, selenium is thought to be associated with the proteins of the plant in organic combination. Application of sulfur to the soil seems to reduce the amount of selenium a plant may absorb. However, in field tests, this has not prevented plants from taking up some selenium and accumulating it. There is a difference in the ability of plants to accumulate this element. Molybdenum and tellurium are sometimes found in plants associated with selenium but their toxicity appears to be independent from the selenium but may add to the poisonous properties of some plants. The two-grooved milk vetch is one of the best indicators of the presence of selenium. In addition, species of *Astragalus* have the ability to absorb selenium and convert it to a soluble form which is absorbed by other plants when the converter plant dies.

2. An early 1949 example of government officials taking the politically correct, but scientifically incorrect path.

[http://lloydgcarter.com/files\\_lgc/1949\\_David\\_Love\\_selenium\\_warning.pdf](http://lloydgcarter.com/files_lgc/1949_David_Love_selenium_warning.pdf)

In February of 1949, USGS geologist David Love issued a warning that selenium in shale soils throughout the American West could pose a serious toxicity problem for wildlife, livestock and humans if those tainted lands were brought into production for farming or mining. Love's 1949 memo was later suppressed by officials of the US Department of Agriculture who worried about its effect on land values in the West. Mr. Love recognized that selenium is toxic in amounts slightly above the nutritional necessity and that selenium can easily enter and poison food chains. He also thought that selenium or other toxic trace elements might be contributory to the high miscarriage rate among women in certain parts of Wyoming.