Abstract

Previous studies have hypothesized that Carbon Disulfide (CS_2) toxicity is based on the chelation of copper and zinc ions by the dithiocarbamate derivatives arising from the reaction of CS_2 with amines. The primary objective of this study was to investigate the potential involvement of trace metals in the metabolism of CS_2 in exposed rats. CS_2 was administered in air at 0, 50, 150, or 500 ppm to separate groups of 60 young adult male Sprague-Dawley rats for 6 hr/day, 5 days/wk, for 6.5 months. The diet consisted of NIH 07 pellets (Ziegler Brothers, Gardner, PA) and tap water from bottles. After the rats had been exposed to CS_2 for 6.5 months, exposure was discontinued. Nine rats from each exposure group including controls were chosen randomly. Cumulative voided urine was collected during 0-8, 8-16, 16-24, and 24-48 hours following the last CS_2 exposure. Thirty-seven metals were measured in the urine by inductively coupled plasma atomic emission spectroscopy (ICP-AES). Linear regression analysis using creatinine normalized concentrations for each exposure group over time revealed statistically significant ($p<0.05$) correlation coefficients for B, Ca, I, Mg, P, Pt, and Sr in the control group; Ca, I, Mg, Mn, and P in the 50 ppm group; Se and Si in the 150 ppm group; and B, Ca, Mg, Mn, and P in the 500 ppm group. With the exception of Pt, Se, and Si, the metal concentrations were decreasing over time. Linear regression analysis using total metal (μg) per time period instead of creatinine normalized (μg/mg) concentrations, yielded similar results. Since the majority of metals with a significant correlation coefficient in both analysis were in the non-exposed group, it is unlikely that the variations were a result of CS_2 exposure. Future studies should concentrate on determining the natural fluctuations of urinary excretion of trace metals in rats.

ACKNOWLEDGMENT

I wish to express my sincere appreciation and gratitude to several individuals for their support and encouragement. First, I am thankful for Dr. Clint Cox and Dr. Shane Que Hee who provided the data that was the basis for this technical report. I especially want to thank Dr. Cox for the unselfish mentoring and support you have given me over the last several years. You knew when to push me and when I needed encouragement. I will always be grateful for your generosity of time and your belief in me. Thanks for serving on my committee!

To Dr. Mike Symons, I want to say a special thanks for agreeing to be a member of my committee even though I was never a student of yours. Thanks for your gracious attitude and input during this project.

To Dr. Ball, my committee chair and advisor, I am deeply indebted to you for your encouragement and incredible patience. Not once did I hear a negative or discouraging word from you even though I most assuredly deserved it. Your support and sense of humor kept me motivated. Thanks for helping me keep life in perspective.

To C.L. Lassiter, I want to say thanks for always being willing to help me with registration semester after semester. You were always a pleasure to deal with. Thank you for all your help.

To my parents, I want to say thanks for teaching me to "Never Quit". Thanks for all your support and encouragement. I could not have better parents. Finally, to my wife Kim and my son Logan. Thanks for your love and understanding. You both have sacrificed more than anybody the last several months. I love you both!

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by

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1.0 Background

1.1 Sources and Uses of CS_2

CS_2 is released from both natural and manmade sources. CS_2 is released in small amounts from several natural sources including volcanoes, soil microbes, and ocean sediments (ATSDR, 1996). Combustion of carbonaceous materials containing sulfur also releases CS_2. Until about 1950, CS_2 was produced commercially by heating charcoal to750-900°C in the presence of vaporized low ash sulfur (ATSDR, 1996). Since the early nineteenth century, CS_2 has been used in the manufacture of sulfur matches, extraction of fats, cold vulcanization of rubber, synthesis of other chemicals (e.g., carbon tetrachloride), as a reactant in the manufacture of cellophane, and in the conversion of cellulose into rayon fibers (ATSDR,1996, Graham, et al. 1995, Klaassen, 1996). Many of these uses have been phased out over the years by replacing CS_2 with other solvents. While the Chemical manufacturing industry still uses CS_2 to synthesize other chemicals, the largest user of CS_2 is still the viscose-rayon industry. Since CS_2 serves as a reagent rather than a solvent in the conversion of cellulose to liquid viscose, less toxic compounds are not currently available (Drexler, et al. 1993). According to the latest data available from the Toxic Release Inventory (TRI, 1998), over 43,446,415 pounds of CS_2 were released to the air during that year; however, the most significant exposures occur in occupational settings. The main route of exposure is through inhalation although significant absorption through the skin can also occur. In occupational settings, a combination of these two routes is likely.

1.2 Chemical and Physical Properties

CS_2 is very volatile, and any releases to the environment results in quick volatilization to the atmosphere (ATSDR, 1996; Klaassen, 1996). However, CS_2 has a low affinity for soil; therefore, if large amounts are spilled, some may be transported into groundwater. The chemical identity and the physical and chemical properties of CS_2 can be found in Tables 1-1 and 1-2, respectively.

1.3 Metabolism

Whether the exposure to CS_2 occurs through inhalation, oral, or dermal route, the absorption is substantial and rapid. The CS_2 is taken up in the blood and distributed throughout the body (ATSDR, 1996). Due to the lipophilic nature of CS_2, it is mainly deposited in lipid-rich organs such as the brain and liver where it is metabolized to thiocarbamates. (ATSDR, 1996; Cox et al., 1992). Teisinger and Soucek (1949) reported that rapid absorption occurred in human subjects. Subjects were exposed by inhalation to 17-51 ppm for 1-4 hours. The amount of CS_2 absorbed was measured by determining levels in inspired air, expired air, blood and urine until it had disappeared from the blood and urine. Teisinger and Soucek (1949) found that 80% of the inhaled CS_2 was retained during the first fifteen minutes of exposure and then decreased to about 40% after 45 minutes. Very little (0.06%) of the CS_2 was eliminated in the urine. Soucek (1957) did another study and reported that 10-30% of

Table 1-1. Chemical Identity of Carbon Disulfide*

Characteristic	Information	Reference
Chemical name	Carbon disulfide	HSDB 1995
Synonym(s)	Carbon bisulphide; carbon disulphide; carbon sulfide; carbon sulphide; dithiocarbonic anhydride; sulphocarbonic anhydride	HSDB 1995
Registered trade name(s)	Weeviltox®	HSDB 1995
	Caswell No. 162®	HSDB 1995
Chemical formula	CS_2	
Chemical structure	S=C=S	
Identification numbers:		
CAS registry	75-15-0	HSDB 1995
NIOSH RTECS	FF6650000	HSDB 1995
EPA hazardous waste	P022 (pure)	HSDB 1995
	F-005 (as a mixture component)	
OHM/TADS	7216633	HSDB 1995
DOT/UN/NA/IMCO shipping	UN 1131; IMCO 6.1	HSDB 1995
HSDB	52	HSDB 1995
NCI	C04591	HSDB 1995

CAS = Chemical Abstracts Services; DOT/UN/NA/IMCO = Department of Transportation/United Nations/North America/International Maritime Dangerous Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/ Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemical Substances

*Source: ATSDR Toxicological Profile 1996

Table 1-2*
Physical and Chemical Properties of Carbon Disulfide

Property	Information	Reference
Molecular weight	76.14	Windholz 1983
Color	Clear, colorless, or faintly yellow	Sax and Lewis 1987
	Colorless	Windholz 1983
Physical state	Highly refractive, mobile liquid	Windholz 1983
Melting point	-110.8°C	Weast 1989
	-111.5°C	HSDB 1995
Boiling point	46.5°C (at 760 torr)	Windholz 1983
Density		
at 15°C	1.27055 g/mL	Windholz 1983
at 20°C	1.2632 g/mL	Windholz 1983
at 30°C	1.2481 g/mL	Windholz 1983
Odor	Purest distillates have sweet, pleasing, and ethereal odor; commercial and reagent grades are foul smelling	Flick 1985; Windholz 1983
Odor threshold:		
Water	0.0026 mg/L (faint odor)	Verschueren 1983
Air	0.31–0.65 mg/m^3 (0.1–0.2 ppm)	ACGIH 1986
	low = 0.0243 mg/m^3 (0.008 ppm)	Ruth 1986
	high = 23.1 mg/m^3 (7.39 ppm)	Ruth 1986
	0.31 mg/m^3 (0.1 ppm) (response in 50% of subjects)	MCA 1968
	0.65 mg/m^3 (0.2 ppm) (response in 100% of subjects)	MCA 1968
	0.05 mg/m^3 (0.02 ppm) (perception in humans)	Verschueren 1983
	0.04 mg/m^3 (0.01 ppm) (nonperception with adverse reflex response in humans)	Verschueren 1983
Solubility:		
Water		
at 20°C	2940 mg/L	Windholz 1983
at 22°C	2300 mg/L	Verschueren 1983
Organic solvents	Miscible with anhydrous methanol, ethanol, ether, benzene, chloroform, carbon tetrachloride, and oils	Windholz 1983

*Source: ATSDR Toxicological Profile 1996

Table 1-2*

Physical and Chemical Properties of Carbon Disulfide (continued)

Property	Information	Reference
Partition coefficients:		
Log K_{ow}	1.84–2.16 (calculated)	Verschueren 1978
Log K_{oc}	1.80	HSDB 1995
Vapor pressure		
at 10°C	127.0 mmHg	Flick 1985
at 10°C	200 mmHg	Verschueren 1983
at 20°C	260 mmHg	Verschueren 1983
at 20°C	297.5 mmHg	Timmerman 1978
at 25°C	352.6 mmHg	Worthing 1987
at 30°C	430 mmHg	Verschueren 1983
Henry's law constant	1.22×10^{-2} atm m^3/mol	EPA 1981
Autoignition temperature	100°C	Windholz 1983; Sax and Lewis 1987
	125–135°C	Worthing 1987
Flashpoint	-30°C (closed cup)	NFPA 1986; Sax and Lewis 1987; Windholz 1983
Flammability limits in air	1–50% (v/v)[a] (explosive range)	Flick 1985; Windholz 1983
	1.3–50%	NFPA 1986; Weiss 1980
Conversion factors	0.32 ppm = 1 mg/m^3	Beauchamp et al. 1983
Explosive limits	lower = 1% upper = 50%	OHMTADS 1995

[a]v/v = percent "volume in volume," which expresses the number of milliliters of pure analyte vapor in 100 milliliters of air mixture (ACGIH 1995)

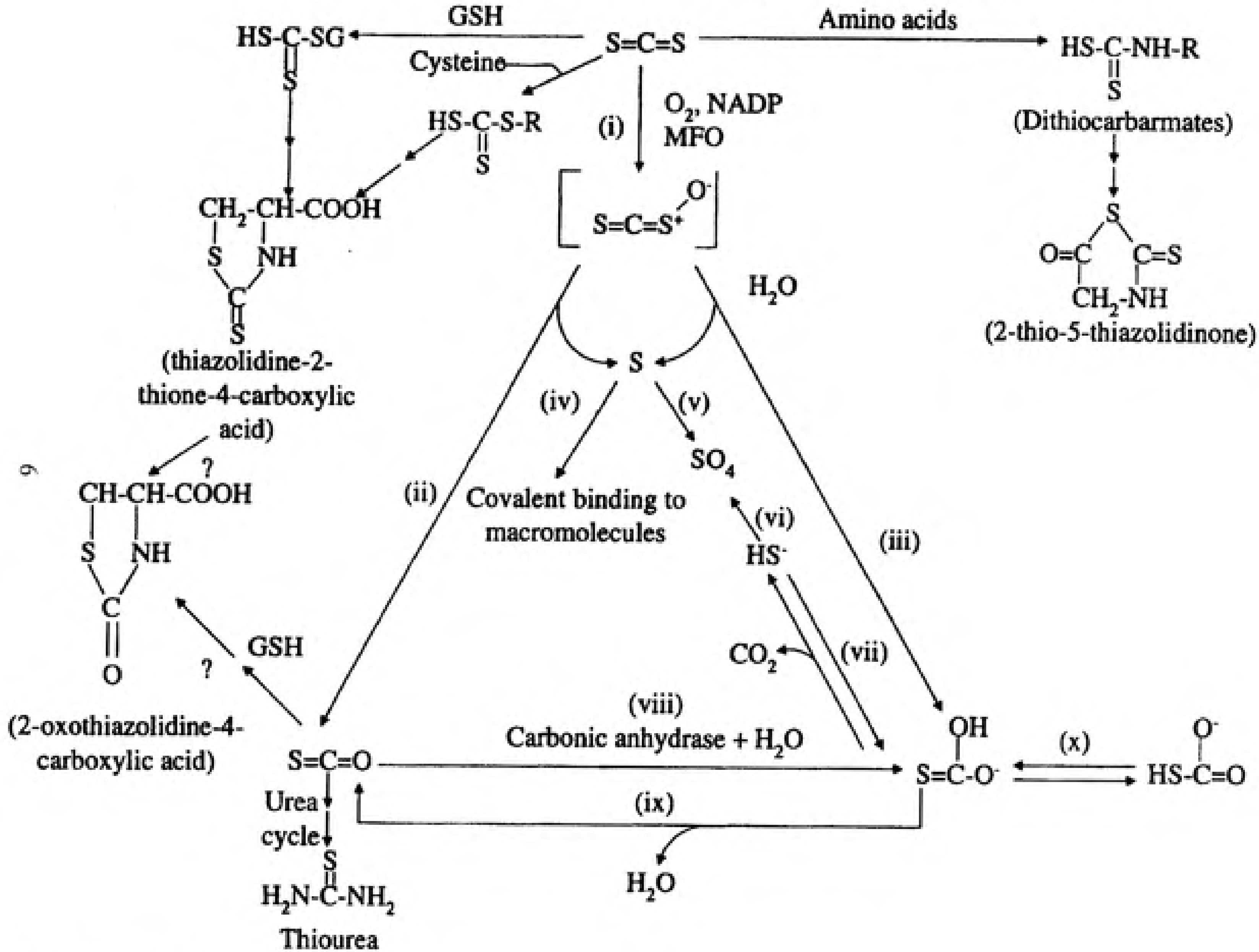
*Source: ATSDR Toxicological Profile 1996

the retained CS_2 was exhaled and less than 1% was excreted in the urine. This indicated that 70-90% of the carbon disulfide was metabolized. Physical exertion increases the inhalation and as a result increases the internal dose of CS_2 (Drexler, et al., 1993; Cox, 1992).

Studies of rats also indicate CS_2 is quickly absorbed after inhalation exposure (ATSDR, 1996). McKenna and DiStefano (1977a) exposed male Sprague-Dawley rats to 640ppm CS_2. They reported an exponential increase in CS_2 in blood which reached steady state after 90 minutes. After exposure stopped, the elimination of blood CS_2 was biphasic with half-lives of 6 and 85 minutes. CS_2 concentrations reached steady state around 4-5 hours. Loss of free CS_2 was rapid in all tissues except the liver and kidneys (McKenna and DiStefano, 1977a).

Beauchamp et al (1983) published a critical review of literature on CS_2 toxicity in 1983. Figure 1-1 depicts the metabolic pathways proposed by Beauchamp et al. Reaction (i) has been demonstrated in vivo animal studies, reactions (ii-v) in vitro studies, and reactions (vi-ix) are proposed metabolic pathways in animals and humans. According to Beauchamp et al., CS_2 is first metabolized by cytochrome P-450 to an unstable oxygen intermediate (reaction i) . The oxygen intermediate either degrades to atomic sulfur and carbonyl sulfide (reaction ii) or hydrolyzes to form atomic sulfur and monothiocarbonate (reaction iii). The Atomic sulfur either covalently binds to macromolecules (reaction iv) or is oxidized to products such as sulfate (reaction v). Unlike animals, the oxidation of

Figure 1-1. Proposed Metabolic Pathways for Carbon Disulfide*



***Source: Beauchamp et al. 1983**

sulfur to sulfate in humans does not contribute significantly to the metabolism of CS_2. The carbonyl sulfide formed in reaction (ii) may be converted to monothiocarbonate by carbonic anhydrase (reaction viii). Monothiocarbonate may degrade in reaction (ix), regenerating carbonyl sulfide or forming carbon dioxide and sulfide bisulfide ion (HS^-) (reaction vii). The HS^- can then be oxidized to sulfate or other nonvolatile metabolites (reaction vi).

1.4 Toxic Effects

CS_2 has been a health concern in the viscose rayon fiber production because of its many effects such as central and peripheral neurotoxicity, increased cardiovascular mortality, injury to the sensory organs, and disturbances in hormonal and reproductive functions (Beauchamp et al.,1983; Riihimaki, 1992). Several epidemiological studies have reported an increase in mortality among viscose rayon workers exposed to carbon disulfide. (Hernberg, et al., 1970, 1973; Tolonen et al. 1975, 1979). These workers were possibly exposed through multiple routes to CS_2 and to other chemicals; therefore, no definitive conclusions can be made regarding inhalation exposure and death. However, some of the studies are discussed further below.

An inhalation study conducted with pregnant rats exposed to 642 ppm CS_2 produced 33% mortality among dams. Pregnant rats exposed to 225 ppm CS_2 produced 35% mortality among pups (Lehotzky et al. 1985; ATSDR, 1996).

Spyker et al reported that 27 people were exposed to CS_2 after a railroad accident. Respiratory changes included reduced vital capacity and decreased partial pressure of arterial oxygen. (Spyker, 1982). No information on exposure concentrations was available.

Several epidemiological studies have reported increased mortality from cardiovascular disease among CS_2 exposed workers (Hernberg, 1970; Tiller, 1968; Balcarova, 1991). Tiller et al. (1968), conducted a retrospective study of 223 viscose rayon workers and reported a statistically significant increase (2.5-fold) in deaths due to coronary heart disease from 1933 to 1962 between CS_2-exposed and nonexposed workers in the same plant. The workers were exposed for more than 10 years to CS_2 levels above 20 ppm (Tiller, 1968; Cox, 1992). Tolonen et al (1979), conducted a prospective mortality study (1967-1977) in which 343 viscose rayon workers were individually matched with workers from a local paper mill. This study reported no significant differences in lifestyles of the two groups. This study also reported a 2.5-fold increase in death due to coronary heart disease among viscose rayon workers. Nurminen and Hernberg (1985) did a follow-up study of the same workers to determine the incidence of cardiovascular mortality from 1967 to 1982. The exposures ranged from 22-10ppm with a decrease in exposure after 1972. For this reason different years were grouped for analysis. From 1967-1974 there was a 4.7-fold increase in mortality compared to the paper mill workers. During the period 1972-1974, the risk ratio dropped to 3.2. Workers with high coronary risk factors were removed from exposure, which resulted in a risk ratio of

1.0 during the years 1974-1982. Balcarova et al. (1991), also reported significantly higher mortality from cardiovascular disease among exposed verses unexposed workers. They also reported that among those exposed, the workers with "high" exposures had a higher mortality rate than those with low exposures to CS_2. Several studies have demonstrated that CS_2 affects liver enzymes. Serum cholesterol sometimes increases after exposure to CS_2, perhaps as a result of increased hepatic cholesterol synthesis (ATSDR, 1996).

The most common and well documented target of CS_2 seems to be the nervous system. Almost every part of the peripheral and central nervous system has been shown to be affected by chronic CS_2 exposure (ATSDR, 1996). Physiological, as well as behavioral, changes have been reported in persons exposed to CS_2. Reported behavioral changes include confusion, irritability, insomnia, overt psychosis, suicidal tendencies, memory defects, and rapid changes in mood (Baker, 1983). Graham et al. (1995) reported that the most common chronic physiological effect is a distal sensorimotor neuropathy. This has been confirmed in animal studies as neurofilamentous axonopathy primarily affecting long axons. (Graham, 1995). Encephalopathy has also been reported after chronic low-level exposures; however, it is still unclear if this is a direct toxicological effect of CS_2 exposure or a result of the increase in cholesterol and higher blood pressure related to CS_2 exposure (Graham, 1995).

One of the main health effects resulting from CS_2 inhalation exposure is neurotoxic effects (ATSDR, 1996). Almost every part of the central and peripheral nervous systems is affected by chronic CS_2 exposure (Baker,1983). There have been a number of studies, both clinical and experimental, that considered the mechanism whereby CS_2 produces neurotoxic lesions (McKenna and DiStefano, 1977; Bus, 1985; Magos, 1972). Some of the hypotheses for CS_2 neuropathy include direct enzymatic inhibition, toxic effect of CS_2 metabolites, and chelation of oligoelements (Maroni et al., 1979). As early as 1956, Soucek and Madlo reported that CS_2 in the body reacts with amino and thiol groups resulting in the formation of dithio and trithiocarbamates (Magos, 1972). These metabolites are known to form non-ionized complexes with polyvalent metal ions (Djuric, 1967). Cohen et al (1956) and Scheel (1965) suspected that chelating structures of these compounds represented a basic mechanism of CS_2 toxicity. Cohen et al and Scheel confirmed biological changes involving metal-shifts in animals exposed to CS_2 (Magos, 1972) through an experiment where rabbits were chronically exposed to 750 ppm CS_2 (Brieger, 1967). The presence of dithiocarbamates and thiazolidone was confirmed by ultraviolet spectrophotometry (Brieger, 1967). The distribution of copper and zinc in the tissues of exposed rabbits differed greatly than the controls. Rabbits that were given dietary supplements containing copper, zinc, cobalt, manganese, iron, and calcium showed less weight loss and no toxic injury (Brieger, 1967). McKenna and Distefano (1977) reported a decrease in the activity of copper-requiring enzyme, dopamine-β-hydroxylase, in response to increased CS_2 inhalation exposure (ATSDR, 1996). Lukas et al. (1974) measured zinc and copper concentrations in the nerve tissues of CS_2 exposed rats. While he did not find a significant difference in the amount of zinc in exposed verses the control rats, there was a significant difference in the level of copper found in the nerve tissue (Lukas et al., 1974). Lukas (1970) also confirmed in an earlier study that rats supplemented with metal salts were less likely to develop peripheral neuropathy. Lukas et al (1974) reported that changes in metal metabolism of peripheral nerve tissue might be a pathological link in the development of CS_2 intoxication. Brieger (1949) noted that depletion of biologically active trace metals could interfere with enzymatic function (Brieger, 1949). Zinc, for example, is an essential co-factor of cytochrome oxidase, tyrosinase, monoamine, phenol, and other tissue oxidases while copper is important for lactate dehydrogenase, carbonic anhydrase, glutamate dehydrogenase, alcohol dehydrogenase, and other enzymes.

1.5 Urinary Markers

1.5.1 Iodine Azide

Beauchamp et al. (1983) reported that 10-30% of the absorbed CS_2 was excreted by the lung and kidney in exposed humans . The remainder was excreted as various metabolites by the kidney. Djuric et al. (1967) established a correlation between CS_2 exposure and urinary excretion of metabolite(s) that catalyzed the reaction of iodine with sodium azide in humans. Cox (1995) confirmed this correlation in CS_2-exposed rats. While the iodine-azide test can reliably detect exposures to CS_2 above16 ppm in air, it does not identify specific metabolites, and it does not correlate well with exposures at levels of concern (below 16 ppm) for occupational exposures.

1.5.2 Thioethers

Total concentration measurements of thio compounds (glutathione conjugates, mercapturic acids, and other sulfur-containing CS_2 metabolites) can also serve as a marker of exposure. Total concentrations of thio compounds correlate well with CS_2 exposure down to about 6 ppm CS_2 in air in CS_2-exposed humans (Beauchamp et al., 1983; Van Doorn et al., 1981; Cox et al., 1995). While total thio compounds correlate well with CS_2 exposure, the compounds are not absolutely specific for CS_2 exposure (ATSDR, 1996).

1.5.3 TTCA

In 1981, van Doorn et al., (1981) identified 2-thiothiazolidine-4-carboxylic acid (TTCA) as a conjugation product of CS_2 and glutathione in the urine of workers exposed to CS_2. Further studies have determined that excretion rates of TTCA in the urine of exposed individuals correlates well with air levels of CS_2 especially once the levels are normalized to urinary creatinine content (ATSDR, 1996; Tolos and Cox, 1989). CS_2 levels of 2.5 ppm and above can be detected with this method (ATSDR, 1996). This makes the TTCA test more sensitive and specific than the iodine-azide test (Cox, 1995).

2.0 Materials and Methods

"*In 1986, National Institute for Occupational Safety and Health (NIOSH) researchers conducted a study (Lynch, 1985) to investigate in a rat animal model a possible mechanism for the etiopathogenesis of atherosclerotic lesions in workers exposed to* CS_2. *Toxic effects on the thyroid were thought to lead to a hypothyroid condition, which triggered increased serum lipids, a predictive biomarker of atherosclerotic disease.*" (Cox, 1998) A subset of these same animals were used for another study by Cox et al. (1998) to measure urinary TTCA in the urine as an indicator of airborne exposure to CS_2. In order to collect as much information as possible from urine "leftover" from the study by Cox et al., inductively coupled plasma atomic emission spectroscopy (ICP-AES) was used to measure 37 metals in the urine. This technical report is based on the ICP-AES metal analysis. Since much of the background information concerning the rats is identical to the study by Cox et al. (1998), the information included below was taken directly from that study (with permission) and is therefore expressed in quotations.

"*Adult male Sprague-Dawley [Crl:CD® (SD) BR] rats weighing 200-250 g were purchased from Charles River Breeding Laboratories, Inc. (Wilmington, MA). The animals were certified murine virus and Mycoplasma pulmonis free on receipt and just before exsanguination. The rats were housed in stainless steel cages inside 4.5-*m^3

stainless steel and glass inhalation chambers (Hinners et al. 1968). The rats were fed NIH 07-pellet diet (Ziefler Brothers, Gardner, PA) and CS_2-free water ad libitum except during exposures." (Cox, 1998)

"*Animal cages were changed and sanitized weekly. Automatic lighting cycles (12 hr on [0700 to 1900 hr]/12 hr off) were maintained. Chamber cage locations were rotated weekly. The rats were individually observed once in the morning and again in the afternoon for clinical signs, morbidity, and mortality.*" (Cox, 1998)

"*Reagent Grade CS_2 was purchased from Matheson Coleman & Bell (Norwood, OH). Prior to, during, and after rat exposure, analysis of the CS_2 to ensure its stability and purity was performed by gas chromatography/mass spectrometry (GC/MS) using NIOSH Method 1600, updated 15 May 1985 (NIOSH 1984) – except that mass spectrometry was also used; and toluene-diluted, 5-µL volumes of CS_2 were injected. CS_2 purity exceeded 99%.*" (Cox, 1998)

"*Inhalation exposures were conducted under dynamic flow conditions at a chamber pressure of -0.254 cm of water relative to ambient atmospheric pressure. Tangential airfeeds were maintained at about 1.1 m^3/min, i.e., 12-15 air changes/hr, to minimize ammonia buildup. CS_2 atmospheres were generated by injecting CS_2 liquid with a fluid metering pump (Fluid Metering, Inc., Oyster Bay, NY) at a constant rate (within + or - 10% of set rate) into the tangential airfeed manifold airstreams located at the top of* *the inhalation chambers to provide targeted airborne concentrations. Chamber atmospheres were sampled and analyzed at least hourly with a calibrated Wilkes-Miran 1-A portable infrared analyzer (Foxboro-Wilkes, Norwalk, CT) to confirm CS_2 concentration, lack of contamination, and uniform individual chamber CS_2 distribution. Temperature and humidity were measured hourly. Targeted airborne concentrations were achieved by changing the metering and the extent of dilution with filtered chamber air. A secondary analytical method was used for the determination of the CS_2 chamber concentrations. This method was based on the reaction of CS_2 with diethylamine and cupric acetate to form yellow-brown cupric diethyldithiocarbamate (McKee 1941 and Tischler 1932). The concentration of the latter was determined on a Beckman DU-6 spectrophotometer (Beckman Instruments, Inc., Fullerton, CA) at 500 nm with a 1-cm cell. The results of two analytical methods agreed within 10% – 96.5% (50 ppm), 99.5% (150 ppm), and 95.0% (500 ppm).*" (Cox, 1998)

"*Separate groups of 60 rats were exposed to air concentrations of CS_2 at 0, 50, 150, and 500 ppm for 6 hr/day and 5 day/wk over 6 months. Body weights of the rats were measured and recorded prior to exposure, weekly, and at termination.*" (Cox, 1998)

"*Rats were exposed for three consecutive days prior to termination of CS_2 exposure. Nine rats from each of the four exposure groups were randomly selected for urine collection, and housed in Nalgene® metabolism cages containing food and water. The enzyme systems of the rats were therefore fully induced. Over a 2-day time period,* *sequential, cumulative urinary voids for each rat were collected in 100-mL polymehtylpentene containers for time periods of 0-8, 8-16, 16-24, and 24-48 hr after cessation of CS_2 exposure.*" (Cox, 1998)

"*Creatinine concentration was determined for each fresh urine sample by the alkaline picrate Jaffe reaction (Tietz 1976). Creatinine measurements and direct observation indicated that some urinary voids had been diluted with spilled drinking water.*" (Cox, 1998)

Appendix A contains the original analysis results from the ICP-AES analysis including; rat identification number, CS2 exposure, time (hours) after exposure stopped, initial and final rat weight (g), urine volume (mL), urine pH, creatinine (mg/L) and metal concentration (μg/mL). Tables in Appendix A are color-coded for observational purposes. Missing data points appear in red, data points below the LQL for that particular metal are yellow, and valid data points are presented in blue. Visual observation of these data reveal numerous missing data points and many more below LQLs (as reported in Que Hee, 1988). The missing data points occurred because first priority for the collected urine was TTCA analysis for the Cox (1998) study. Often, there was not enough volume of urine left to also run the ICP-AES analysis; therefore, limiting the data points for this study. Metals with 50% or more data points below LQLs were the same for all exposure groups including controls. Each metal with 50% or more data points below the LQL was removed from further analysis. The remaining data points that were below the LQL were replaced with ½ of the LQL for that specific metal. Appendix B contains the remaining metals with < LQL values replaced . Further analysis was based on this data set in Appendix B. Statistical analyses were performed using computerized software – StatMost™ Version 3.00 (DataMost Corporation, Salt Lake City, UT).

3.0 Results

Linear regression analysis was used to determine if there was a significant correlation ($p<0.05$) between the concentration of each metal (μg/mg creatinine) excreted over time (0-8, 8-16, 16-24, 24-48 hours after CS_2 exposure ceased) for each exposure group (0, 50, 150, and 500 ppm). Since the metal concentration results represented a given time period (e.g. 0-8 hours) rather than a specific time point, the midpoint of each time period was used for regression analysis purposes. Therefore 4, 12, 20, and 36 were used to represent hours after exposure stopped rather than 8, 16, 24, and 48. Table 3.1 lists the metals from each exposure group that had a correlation with time (0-8, 8-16, 16-24, and 24-48 hrs) at a statistically significant level of $p<0.05$.

Table 3.1
Metals (μg/mg creatinine) with
Significant ($p<0.05$) Correlation with Time

0 ppm	50 ppm	150 ppm	500 ppm
B			B
Ca	Ca		Ca
I	I		
Mg	Mg		Mg
	Mn		Mn
P	P		P
Pt			
		Se	
		Si	
Sr			

Regression analysis results for each of these metals by exposure group are presented in Tables 3.2 - 3.5. Results for each metal include the predictive equation, correlation coefficient, and p value. Regression equations indicate that the majority of metal concentrations were decreasing over time after exposure stopped. Only Pt, Se, and Si indicated increasing concentrations over time. Corresponding graphs for these analyses are found in Appendix C.

Table 3.2
0 ppm
Linear Regression Analysis Results
Metal (μg/mg creatinine) vs Time (t)

Correlation	**Linear Regression Equation**	**Correlation Coefficient**	**p value**
B vs Time	B μg/mg creatinine = 0.4828 - 0.0100 t	0.61	0.0117
Ca vs Time	Ca μg/mg creatinine = 13.0895 - 0.2516 t	0.74	0.0012
I vs Time	I μg/mg creatinine = 1.9328 - 0.0458 t	0.56	0.0242
Mg vs Time	Mg μg/mg creatinine = 33.63 - 0.7824 t	0.71	0.0022
P vs Time	P μg/mg creatinine = 175.54 - 1.6183 t	0.62	0.0102
Pt vs Time	Pt μg/mg creatinine = -0.0059 + 0.0008 t	0.73	0.0013
Sr vs Time	Sr μg/mg creatinine = 0.0319 - 0.0005 t	0.67	0.0040

Table 3.3
50 ppm
Linear Regression Analysis Results
Metal (µg/mg creatinine) vs Time (t)

Correlation	Predictive Equation	Correlation Coefficient	p value
Ca vs Time	Ca µg/mg creatinine = 8.5654 - 0.1206 t	0.55	0.0265
I vs Time	I µg/mg creatinine = 1.9418 - 0.0491 t	0.54	0.0317
Mg vs Time	Mg µg/mg creatinine = 28.4729 - 0.6478 t	0.62	0.0101
Mn vs Time	Mn µg/mg creatinine = 0.0136 - 0.0003 t	0.57	0.0195
P vs Time	P µg/mg creatinine = 184.7204 - 2.4607 t	0.53	0.0330

Table 3.4
150 ppm
Linear Regression Analysis Results
Metal (µg/mg creatinine) vs Time (t)

Correlation	Predictive Equation	Correlation Coefficient	p value
Se vs Time	Se µg/mg creatinine = 0.0057 + 0.0009 t	0.59	0.0110
Si vs Time	Si µg/mg creatinine = 0.2507 + 0.0113 t	0.57	0.0180

Table 3.5
500 ppm
Linear Regression Analysis Results
Metal (μg/mg creatinine) vs Time (t)

Correlation	Predictive Equation	Correlation Coefficient	p value
B vs Time	B μg/mg creatinine = 0.5128 - 0.0086 t	0.53	0.0224
Ca vs Time	Ca μg/mg creatinine = 9.1675 - 0.1447 t	0.57	0.0134
Mg vs Time	Mg μg/mg creatinine = 28.3764 - 0.6696 t	0.72	0.0008
Mn vs Time	Mn μg/mg creatinine = 0.0220 - 0.0004 t	0.63	0.0049
P vs Time	P μg/mg creatinine = 193.4145 - 1.6696 t	0.47	0.0482
Sr vs Time	Sr μg/mg creatinine = 0.0238 - 0.0003 t	0.57	0.0142

To compare exposure groups, linear regression was used for each urine collection period (0-8, 8-16, 16-24, 24-48 hours) across exposure groups (0, 50, 150, and 500 ppm). Metals with significant ($p<0.05$) correlation with exposure groups (0, 50, 150, 500 ppm) are presented in Table 3.6. Results for each metal include the predictive equation, correlation coefficient, and p value. All four significant correlations occurred in the 24-48 hour urine collection period and indicate increased excretion as CS_2 exposure increased. Corresponding graphs for these analyses are in Appendix D.

Table 3.6
Linear Regression Analysis
24-48hr Urine Collection Period
Metals µg/mg creatinine with $p<0.05$

Correlation	Predictive Equation	Correlation Coefficient	p value
K vs CS_2 Exposure	K µg/mg creatinine = 407.7171 + 0.1402 CS_2	0.37	0.0384
P vs CS_2 Exposure	P µg/mg creatinine = 106.8873 + 0.0496 CS_2	0.39	0.0289
Li vs CS_2 Exposure	Li µg/mg creatinine = 0.0265 + 0.0000 CS_2	0.39	0.0305
S vs CS_2 Exposure	S µg/mg creatinine = 176.6358 + 0.0625 CS_2	0.41	0.0232

Because urine production can vary from animal to animal and even day to day with the same animal, concentrations are routinely "normalized" using urine properties that fluctuate less than water volume. Historically creatinine has been used as one such "normalizer". Another method often used is to report the total amount collected over a given time period. Observation of the mean creatinine levels for this study indicates very little fluctuation among samples; hence, the use of creatinine normalized data. While creatinine is most likely the best normalizer for these data, an attempt was also made to examine the data using total metal (µg) per time period. In order to do this, the total metal (µg) for the 24-48 urine collection period had to be divided by 3 so that comparisons could be made with the other three (8 hour) collection periods. Linear regression was used to determine the correlation between metals (total metal in µg per time period) and time after exposure stopped for each exposure group. For the 24-48 hour period, "40" was used rather than 48 since total metal mass had been divided by three and "40" represents the middle 8 hour time period of 24-48. Table 3.7 is a list of metals by exposure group with significant ($p<0.05$) correlations over time. Regression analysis results for each of these metals by exposure group are presented in tables 3.8 - 3.11. Results for each metal include the predictive equation, correlation coefficient, and p value. Regression equations indicate that the majority of metal concentrations were decreasing over time after exposure stopped. Once again, only Pt, Se, and Si indicated increasing concentrations over time. Corresponding graphs for these analyses are in Appendix E.

Table 3.7
Metals (total μg) with
Significant ($p<0.05$) Correlation with Time

0 ppm	50 ppm	150 ppm	500 ppm
B			B
		C	
Ca			Ca
Cu			
I	I		I
K			K
Li			Li
Mn			Mn
Mg	Mg		Mg
Na			
P			P
Pt			
S			
		Se	
		Si	
Sr			Sr
Zn			

Table 3.8
0 ppm
Linear Regression Analysis Results
Metal (total µg) vs Time (t)

Correlation	Predictive Equation	Correlation Coefficient	p value
B vs Time	B µg = 5.1137 - 0.1158 t	0.58	0.0163
Ca vs Time	Ca µg = 113.5023 - 2.3780 t	0.79	0.0003
Cu vs Time	Cu µg = 0.6514 - 0.0131 t	0.55	0.0269
I vs Time	I µg = 13.2661 - 0.2921 t	0.64	0.0073
K vs Time	K µg = 5456.44 - 89.9316 t	0.51	0.0432
Li vs Time	Li µg = 0.3635 - 0.0060 t	0.58	0.0168
Mn vs Time	Mn µg = 0.1338 - 0.0028 t	0.55	0.0263
Mg vs Time	Mg µg = 285.2467 - 6.4519 t	0.75	0.0007
Na vs Time	Na µg = 2316.9613 - 33.9608 t	0.62	0.0114
P vs Time	P µg = 1676.1717 - 29.0391 t	0.64	0.0066
Pt vs Time	Pt µg = -0.0133 + 0.0037 t	0.55	0.0254
S vs Time	S µg = 1760.9376 - 23.3931 t	0.50	0.047
Sr vs Time	Sr µg = 0.2895 - 0.0056 t	0.73	0.0012
Zn vs Time	Zn µg = 0.2895 - 0.0056 t	0.73	0.0012

Table 3.9
50 ppm
Linear Regression Analysis Results
Metal (total µg)) vs Time (t)

Correlation	Predictive Equation	Correlation Coefficient	p value
I vs Time	I µg = 12.4440 - 0.2830 t	0.53	0.0312
Mg vs Time	Mg µg = 197.2188 - 3.9628 t	0.52	0.0408

Table 3.10
150 ppm
Linear Regression Analysis Results
Metal (total μg) vs Time (t)

Correlation	Predictive Equation	Correlation Coefficient	p value
C vs Time	C μg = 120188.7993 - 1989.6264 t	0.54	0.0264
Se vs Time	Se μg = 0.0330 + 0.0056 t	0.57	0.0174
Si vs Time	Si μg = 1.7348 + 0.0685 t	0.52	0.0323

Table 3.11
500 ppm
Linear Regression Analysis Results
Metal (total μg) vs Time (t)

Correlation	Predictive Equation	Correlation Coefficient	p value
B vs time	B μg = 3.7046 - 0.0730 t	0.74	0.0004
Ca vs time	Ca μg = 59.9205 - 1.0251 t	0.72	0.0008
I vs time	I μg = 11.3332 - 0.2507 t	0.50	0.0321
K vs time	K μg = 3942.0233 - 43.9416 t	0.58	0.0110
Li vs time	Li μg = 0.2400 - 0.0023 t	0.59	0.0092
Mg vs time	Mg μg = 186.6167 - 4.1076 t	0.77	0.0002
Mn vs time	Mn μg = 0.1442 - 0.0028 t	0.68	0.0019
P vs time	P μg = 1329.6915 - 17.7231 t	0.74	0.0004
Sr vs time	Sr μg = 0.1594 - 0.0023 t	0.83	0.00002

Linear regression was also used for each urine collection period (0-8, 8-16, 16-24, 24-48 hours) across exposure groups (0, 50, 150, and 500 ppm) using total metals (µg). The only metal with a significant ($p<0.05$) correlation with exposure groups (0, 50, 150, 500 ppm) was manganese (Mn) and only in the 16-24hr urine collection period. Results are presented in Table 3.12. Results include the predictive equation, correlation coefficient, and p value. The regression equation indicates increasing excretion as CS_2 exposure increases. A corresponding graph can be found in Appendix F.

Table 3.12
Linear Regression Analysis
16-24hr Urine Collection Period
Metal (total µg) with $p<0.05$

Correlation	Predictive Equation	Correlation Coefficient	p value
Mn vs CS_2 exposure	Mn µg = 0.0151 + 0.0002 CS_2	0.98	0.0172

4.0 Discussion and Conclusions

The primary objective of this study was to investigate the potential involvement of trace metals in the metabolism of CS_2 in exposed rats by measuring metal concentrations in the urine. Urine analysis, especially in rats, presents difficulties not only in sample collection but also in sample analysis. Sample collection can be difficult because rats do not drink or urinate on command. This study was limited mainly due to the fact that the main purpose of the original study was not designed for collecting urinary excretion of metals in CS_2-exposed rats. Collection of the metal data was "added" onto the end of another study. As a result, there was not always enough urine left over after the initial analysis to run metal analysis. This severely limited the number of valid data points.

As discussed earlier, concentrations are routinely "normalized" using urine properties that fluctuate less than water volume. For this study, linear regression analysis was performed using both creatinine normalized (µg/mg) data and total metal mass (µg) per time period.. One basic assumption in using linear regression is that the measurements are independent of each other. Using linear regression to determine the correlation of metal concentration (or mass) over time violates this assumption due to the fact that the comparisons are within the same rats in each time period. However, in this experiment, every effort was made to eliminate any variables that might effect the results over time such as constant food and water sources, light/dark schedule, identical housing, etc. Using linear regression for determining the correlation between metal concentration (or mass) across exposure groups does satisfy the assumption of independence because the comparisons are between different groups of rats.

As depicted in Table 3.1, linear regression using creatinine normalized data revealed several metals that correlated with time (8-48 hr) after exposure stopped for each exposure group (0, 50, 150, and 500 ppm). Correlation coefficients for these metals ranged from 0.47-0.74 signifying a weak to moderate correlation. While there does seem to be some change in metal concentrations occurring over time, it is difficult to attribute the change to CS_2 exposure because of the large number of metals with significant correlations in the unexposed (0 ppm control) group. While statistically significant, the question is whether there is a real difference between the controls and the exposed groups? In other words, is there a biological significance? In order to make a comparison, the concentrations from each time period for a given metal in the control group were pooled to give a mean metal concentration (and standard deviation). The resulting mean was compared to the y-intercept value and predicted value of the corresponding regression equations. Using calcium as an example, this comparison is depicted in Table 4.1 below.

Table 4.1
Comparison of Linear Regression Results for Ca (ug/mg creatinine)

Exposure Group	Predictive Equation	Value at time 36hr
50 ppm	Ca µg/mg creatinine = 8.5654 - 0.1206 t	4.22
150 ppm	Ca µg/mg creatinine = 8.2810 - 0.0733 t	5.64
500 ppm	Ca µg/mg creatinine = 9.1675 - 0.1447 t	3.95
Mean Ca (ug/mg creatinine) for control rats = 7.3 (+/- 4.67)		

While linear regression analysis for Ca concentrations over time in the 50 and 500 ppm exposure groups indicated a significant correlation ($p<0.05$), Table 4.1 reveals that the y-intercept and predicted values for each exposure group are within one standard deviation of the calculated mean of the unexposed (control) group. Similar comparisons of the other metals with significant correlations revealed that most were within the range of one standard deviation of the calculated mean for the control group. I, Se, and Mn were the exceptions due to the y-intercept being just outside one standard deviation of the calculated mean. With the exception of Mn, Se, and Si, the metals with significant correlations over time in the exposed groups (50, 150, and 500 ppm) are the same metals as those with significant correlations in the unexposed group. This seems to indicate that there is some natural variation in these metal concentrations over time. This makes it difficult to attribute these changes to CS_2 exposure.

Linear regression using total metals (μg) vs time after exposure stopped, revealed similar results (Table 3.7). A large number of the metals with significant correlations were in the nonexposed group. Comparison of the regression equations for metals indicating a significant correlation ($p<0.05$) with time again revealed that most y-intercept and predicted values were within one standard deviation of the calculated mean value of the control rats. Phosphorus (P) seemed to be the only exception to this due to a much larger regression coefficient in the control group.

As depicted in Table 3.6, linear regression analysis of metal concentration (μg/mg) for each urine collection period (0-8, 8-16, 16-24, and 24-48 hr) across exposure groups

(0, 50, 150, and 500 ppm) revealed weak but statistically significant ($p<0.05$) correlations with increasing concentrations of K, P, Li, and S, as CS_2 exposure increased, but only in the 24-48 hr time period. Using total metals (μg), linear regression revealed a statistically significant correlation over exposure groups only for Mn in the 16-24 hr urine collection period (Table 3.12). To determine if these differences were biologically significant, a student t test using 0.95 confidence interval levels was used to compare the control group (0 ppm) mean with the mean from each exposed group (50, 150, and 500 ppm). This was done for each metal using both the concentration (μg/mg) means and total metal mass means (μg) for every metal. None of the student t tests revealed a significant difference between the means.

While this study does indicate that trace metals changed (statistically) over time and over exposure groups, the changes seem to be within the variations seen in the unexposed rats. With the exception of Pt, Si, and Se, linear regression over time revealed a decrease in metal concentration over time. This seemingly natural fluctuation of metal excretion makes it difficult to determine if the changes in the exposed groups are due to CS_2 exposure. Based on the results of this study, there is no indication of strong effects on urinary excretion of metals in CS_2 exposed rats. Therefore, even though there seems to be a statistically significant change in some metals, the results of this study indicate that the changes do not have any biological significance since they do not differ greatly from the non exposed rats.

Further, as the tests involved multiple metals (37), it is appropriate to apply the Bonferroni correction (0.05 /number of metals analyzed) to determine the true significance level. With this correction, many fewer values satisfy the stricter criterion of statistical significance ($P < 0.05/37$).

5.0 Suggestions for Further Study

As discussed at the beginning of this report, this experiment was not originally designed to study excretion of metals in CS_2 exposed rats. The metal excretion data were collected at the end of the Cox (1992) study due to excess urine and the desire to maximize the amount of information gathered from the exposed rats. If the experiment was designed to gather metal excretion data from CS_2 exposed rats, there are several things that might improve the study.

First, it would be beneficial to better understand the natural fluctuations of metals in unexposed rats. This could be accomplished by collecting urine from unexposed rats over an extended time period. It might also be accomplished by searching the literature for other rat urine studies and compiling information on control rats used in those studies. Second, if the study was done again, the CS_2 dose and/or the exposure times could be increased in order to get the response to "stand out" as compared to the controls. In the current study, if there were responses, they were among the "noise" or background of the unexposed group and difficult to distinguish. Increasing the dose may not be an option due to the possibility that doses above 500 ppm may be lethal. Another possible improvement would be to use a more acute exposure (e.g., 2 weeks) rather than the 6 months that the rats were exposed in this study. One of the best ways to improve this study would be to increase the number of rats. This would increase the cost significantly but would also help make sure that there was enough urine to run the necessary analysis and decrease the variation that comes with small numbers. Finally, using a longer follow-up time might determine if the fluctuations seen in this study continue or stabilize.

6.0 References

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7.0 Appendices

7.1 Appendix A ---- Laboratory Data

Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	Ag µg/mL	Al µg/mL	As µg/mL	Au µg/mL	B µg/mL	Ba µg/mL	Be µg/mL	Ca µg/mL	Cd µg/mL	Co µg/mL	Cr µg/mL
2040	0	0.91	7.5	7.5	8	-0.043	0.0162	-0.1666	-0.0011	0.1662	0.0066	-0.0004	10.14	0.0004	0.002	-0.003
2040	0	0.49	15	22.5	16	-0.0096	0.0009	-0.0154	0.0007	0.2376	0.002	0	5.108	-0.0002	-0.0036	-0.0005
2040	0	1.39	3.5	26	24											
2040	0	0.82	20.5	46.5	48	0.0009	0.0252	-0.0778	0.007	-0.3463	0.0017	0.0003	4.566	0.0001	-0.0031	-0.0006
2061	0	0.96	19.5	19.5	8	-0.0072	0.0111	0.0446	-0.003	0.5446	0.0064	-0.0003	6.55	0.0012	0.004	0.0002
2061	0	0.66	9	28.5	16	-0.0086	0.0087	-0.0237	0	0.0734	0.0015	0.0002	3.463	-0.0004	-0.0025	-0.0021
2061	0	1.56	4.5	33	24											
2061	0	1.64	8.5	41.5	48	-0.0043	0.0344	-0.0787	-0.0002	-0.2866	0.0033	0.0004	4.596	-0.0001	0.0076	-0.0025
2164	0	1.87	4.5	4.5	8											
2164	0	1.06	6.5	11	16											
2164	0	1.12	4	15	24											
2164	0	1.71	7.5	22.5	48	-0.0416	0.0341	-0.0606	-0.0007	0.676	0.0041	-0.0003	2.673	0.0024	0.0036	-0.0012
2175	0	1.71	5.5	5.5	8											
2175	0	2.55	2	7.5	16											
2175	0	2.8	2	9.5	24											
2175	0	2.41	6	15.5	48											
2193	0	1.15	6.5	6.5	8											
2193	0	0.87	7.5	14	16	-0.0336	0.0137	-0.0977	0.003	0.4729	0.0062	-0.0002	10.68	0.0011	0.0059	-0.0008
2193	0	1.52	3	17	24											
2193	0	1.62	7.5	24.5	48	-0.0035	0.018	-0.1146	0.0007	-0.1699	0.0032	0.0004	5.248	-0.0002	0.0018	-0.0024
2200	0	1.73	4.5	4.5	8											
2200	0	0.7	7.5	12	16	-0.012	0.0113	-0.0457	0	0.2952	0.0026	-0.0002	5.758	0.0009	0.006	-0.0018
2200	0	2.01	4	16	24											
2200	0	1.56	9.5	25.5	48	-0.0035	0.0256	-0.1355	0.004	-0.2952	0.0006	0.0004	6.09	0.0006	-0.0013	-0.0035
2299	0	1.35	4.5	4.5	8											
2299	0	1.39	4	8.5	16											
2299	0	1.87	3	11.5	24											
2299	0	1.44	7.5	19	48	0.007	0.0084	-0.026	0.0018	-0.1061	0.0021	0.0005	5.463	0	-0.0029	-0.0003
2381	0	1.9	4.5	4.5	8											
2381	0	0.43	9.5	14	16	-0.0155	0.0156	0.0062	0.0016	0.1007	0.0022	-0.0002	3.147	0.0004	0.0062	-0.0003
2381	0	1.47	4	18	24											
2381	0	0.96	20.5	38.5	48	0.006	0.0121	0.0102	0	0.4171	0.0032	-0.0003	5.757	0.0002	0.0116	-0.0006
2392	0	1.47	5.5	5.5	8											
2392	0	1.09	6.5	12	16	-0.0576	0.029	-0.2366	0.0008	0.5799	0.0024	-0.0003	16.1	0.0013	0.0027	-0.0019
2392	0	1.83	3	15	24											
2392	0	1.48	9.5	24.5	48	-0.0096	0.0101	-0.1174	0.0033	-0.2414	0.0021	0.0004	4.915	0.0009	0.0102	-0.0037

Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	Cu µg/mL	Fe µg/mL	Hg µg/mL	I µg/mL	In µg/mL	K µg/mL	Li µg/mL	Mg µg/mL	Mn µg/mL	Mo µg/mL	Na µg/mL	Ni µg/mL
2040	0	0.91	7.5	7.5	8	0.129	0.0803	-0.0074	0.851	-0.031	322.7	0.0223	10.26	0.0181	0.0442	-1835	0.0061
2040	0	0.49	15	22.5	16	0.0098	0.0247	-0.0042	1.276	-0.096	297	0.0169	15.08	0.0087	0.052	514.3	0.0004
2040	0	1.39	3.5	26	24												
2040	0	0.62	20.5	46.5	48	0.0129	0.0331	-0.0062	-0.5944	-0.0657	358.3	0.0236	0.4533	0.0006	0.0703	2159	-0.0072
2061	0	0.96	19.5	19.5	8	0.0658	0.1022	-0.0042	0.322	-0.0647	583.8	0.0339	20.11	0.0096	0.1044	494.7	0.0015
2061	0	0.66	9	28.5	16	0.0267	0.0681	-0.0178	1.378	0.0358	150.3	0.0121	15.34	0.0065	0.0287	-3762	-0.0202
2061	0	1.56	4.5	33	24												
2061	0	1.64	8.5	41.5	48	0.1006	0.1832	-0.017	-0.9141	-0.0808	650.6	0.0399	2.046	0.0021	0.1271	4468	-0.0036
2164	0	1.87	4.5	4.5	8												
2164	0	1.06	6.5	11	16												
2164	0	1.12	4	15	24												
2164	0	1.71	7.5	22.5	48	0.0497	0.0716	0.0014	-0.7932	-0.2635	885.5	0.0455	0.2897	0.0005	0.127	1210	-0.0011
2175	0	1.71	5.5	5.5	8												
2175	0	2.55	2	7.5	16												
2175	0	2.8	2	9.5	24												
2175	0	2.41	6	15.5	48												
2193	0	1.15	6.5	6.5	8												
2193	0	0.87	7.5	14	16	0.0913	0.1107	-0.007	-0.4181	-0.1274	538.1	0.0850	17.25	0.0057	0.0581	653.3	-0.0011
2193	0	1.52	3	17	24												
2193	0	1.62	7.5	24.5	48	0.097	0.1336	-0.0262	-2.86	-0.1473	676	0.0428	0.3579	-0.0003	0.1429	3963	-0.0116
2200	0	1.73	4.5	4.5	8												
2200	0	0.7	7.5	12	16	0.027	0.055	-0.0223	1.804	-0.0699	397.6	0.0298	19.86	0.0147	0.0787	-7770	0.0073
2200	0	2.01	4	16	24												
2200	0	1.56	9.5	25.5	48	0.0359	0.0817	-0.02	-1.614	-0.021	565.7	0.0374	0.1474	0	0.1113	3730	0.0076
2299	0	1.35	4.5	4.5	8												
2299	0	1.39	4	8.5	16												
2299	0	1.87	3	11.5	24												
2299	0	1.44	7.5	19	48	0.0333	0.0755	-0.0231	-3.596	-0.0907	736.7	0.0474	0.2751	-0.0003	0.1501	5044	-0.0063
2381	0	1.9	4.5	4.5	8												
2381	0	0.43	9.5	14	16	0.0144	0.0264	-0.0238	1.449	0.0881	204.9	0.0173	18.57	0.0101	0.0346	-4494	-0.0004
2381	0	1.47	4	18	24												
2381	0	0.96	20.5	38.5	48	0.0192	0.111	-0.0045	1.231	-0.1246	486.2	0.0293	32.97	0.029	0.0742	-5786	-0.0057
2392	0	1.47	5.5	5.5	8												
2392	0	1.09	6.5	12	16	0.1082	0.0255	-0.007	0.9413	-0.3426	647.6	0.0447	31.64	0.0026	0.1113	1367	-0.0056
2392	0	1.83	3	15	24												
2392	0	1.48	9.5	24.5	48	0.0546	0.0672	-0.0185	-1.564	-0.1109	831.7	0.0429	0.249	0.0003	0.1271	4457	-0.0004

Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	P µg/mL	Pb µg/mL	Pt µg/mL	S µg/mL	Sb µg/mL	Se µg/mL	Si µg/mL	Sn µg/mL	Sr µg/mL	Ti µg/mL	Tl µg/mL	V µg/mL	Zn µg/mL	C µg/mL
2040	0	0.91	7.5	7.5	8	103.5	0.0146	0.0011	125.9	-0.0005	0.0084	0.1811	-0.148	0.0236	-0.0015	0.056	0.002	0.0558	12024
2040	0	0.49	15	22.5	16	50.36	0.0008	-0.0056	98.0	0.003	-0.0182	0.2042	-0.0732	0.0157	-0.0004	0.0326	-0.0009	0.0346	3175
2040	0	1.39	3.5	26	24														
2040	0	0.82	20.5	46.5	48	66.6	-0.0117	0.0449	134.7	0.0118	0.0576	0.2366	-0.0717	0.0136	0.0013	0.0717	0.0021	0.036	8096
2061	0	0.98	19.5	19.5	8	147.5	0.0017	0.0071	166.5	0.003	0.0144	0.4073	-0.0527	0.0205	-0.0008	0.0411	-0.0013	0.1033	2491
2061	0	0.66	9	28.5	16	81.1	-0.011	-0.0046	81.86	-0.0147	-0.1351	0.1386	-0.132	0.0099	-0.0019	0.0373	0.0009	0.039	3409
2061	0	1.56	4.5	33	24														
2061	0	1.64	8.5	41.5	48	165.1	-0.0166	0.0605	312	-0.0046	0.0266	0.9799	-0.2252	0.0166	-0.0008	0.0673	0.0017	0.1282	6660
2164	0	1.87	4.5	4.5	8														
2164	0	1.06	6.5	11	16														
2164	0	1.12	4	15	24														
2164	0	1.71	7.5	22.5	48	170.2	-0.0021	0.0369	226.2	0.0074	-0.0048	0.7684	-0.053	0.0162	0	0.0643	0.0002	0.0621	11634
2175	0	1.71	5.5	5.5	8														
2175	0	2.56	2	7.5	16														
2175	0	2.8	2	9.5	24														
2175	0	2.41	6	15.5	48														
2193	0	1.16	6.5	6.5	8														
2193	0	0.87	7.5	14	16	156.6	0.005	-0.0092	191.9	-0.003	-0.0048	0.6862	-0.1926	0.0339	0.0001	0.0414	-0.0002	0.0645	12033
2193	0	1.62	3	17	24														
2193	0	1.62	7.5	24.5	48	235.6	-0.002	0.024	336.5	-0.0082	0.1176	1.161	-0.2967	0.034	-0.0001	0.0053	0.0022	0.1636	13332
2200	0	1.73	4.5	4.5	8														
2200	0	0.7	7.5	12	16	132.5	-0.0062	-0.0402	166.6	-0.0013	-0.027	0.0286	-0.2	0.0191	-0.0028	0.0636	0.0015	0.0376	5361
2200	0	2.01	4	16	24														
2200	0	1.56	9.5	25.5	48	169.1	-0.003	0.0486	266	0.0128	0.0613	0.7413	-0.16	0.0155	-0.0009	0.1326	0.0036	0.0495	14128
2299	0	1.35	4.5	4.5	8														
2299	0	1.39	4	8.5	16														
2299	0	1.87	3	11.5	24														
2299	0	1.44	7.5	19	48	173.5	-0.0041	0.0644	360.7	-0.0062	0.0686	0.7869	-0.1103	0.0221	-0.0004	0.0276	0.0017	0.0646	5602
2381	0	1.9	4.5	4.5	8														
2381	0	0.43	9.5	14	16	72.87	-0.0124	-0.0268	91.56	0.0029	-0.0646	0.4375	-0.2036	0.0106	-0.0027	0.1044	0.0019	0.0255	1274
2381	0	1.47	4	18	24														
2381	0	0.98	20.5	38.5	48	130.1	-0.0043	-0.0341	165.6	-0.0085	-0.0324	0.787	-0.2394	0.0196	-0.0011	0.0092	0.002	0.0456	2074
2392	0	1.47	5.5	5.5	8														
2392	0	1.09	6.5	12	16	221.2	0.0054	0.0159	714.3	-0.0006	0.0614	0.8695	-0.1168	0.0409	-0.0004	0.0478	0.0001	0.0673	21818
2392	0	1.83	3	15	24														
2392	0	1.48	9.5	24.5	48	182.7	-0.0112	0.0624	294.7	-0.0013	0.0662	0.6081	-0.1468	0.0196	-0.0008	0.0664	0.0026	0.0626	15986

Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	Ag µg/mL	Al µg/mL	As µg/mL	Au µg/mL	B µg/mL	Ba µg/mL	Be µg/mL	Ca µg/mL	Cd µg/mL	Co µg/mL	Cr µg/mL
2078	50	1.81	3	3	8											
2078	50	0.75	7.5	10.5	16	-0.004	0.0128	0.0232	-0.0047	0.2851	0.0023	-0.0003	2.916	0.0009	-0.0019	-0.0005
2078	50	1.13	4	14.5	24											
2078	50	0.99	14.5	29	48	-0.0009	0.0118	-0.0523	0.0063	-0.3414	0.0016	0.0004	3.493	-0.0001	0.0026	-0.0001
2082	50	1.53	4	4	8											
2082	50	0.61	7.5	11.5	16	0	0.0026	-0.0263	-0.0018	0.196	0.0021	-0.0003	2.852	-0.0006	0.0017	-0.002
2082	50	2.27	3	14.5	24											
2082	50	1.05	25.5	40	48	-0.0512	0.0222	-0.131	-0.004	0.3606	0.0047	-0.0003	5.111	0.0001	-0.0029	-0.0016
2092	50	1.42	4	4	8											
2092	50	0.56	9	13	16	-0.0129	0.0191	-0.0234	0.0026	0.1476	0.0023	-0.0002	2.614	0.0001	0.0042	-0.0021
2092	50	1.28	4	17	24											
2092	50	1.17	16.5	33.5	48	-0.0181	0.0162	-0.1025	0.002	0.5162	0.0033	-0.0002	3.976	0.001	0.0032	-0.0037
2097	50	1.9	3.5	3.5	8											
2097	50	1.55	6.5	10	16											
2097	50	1.98	2	12	24											
2097	50	2.23	7.5	19.5	48	-0.0232	0.0222	0.0427	-0.0022	1.036	0.0047	-0.0002	7.716	0.0021	0.001	-0.0003
2155	50	1.15	6	6	8											
2155	50	0.37	26.5	32.5	16	-0.0112	0.0078	-0.0375	0.0026	0.1031	0.0045	-0.0002	4.705	0	0.0047	-0.0012
2155	50	0.99	6.5	39	24	-0.012	-0.0948	0.0039	-0.0328	0.3213	-0.0018	-0.0007	5.566	-0.004	-0.0069	-0.0052
2155	50	0.81	37.5	76.5	48	0.0122	0.0143	-0.0447	0.0033	-0.5697	0.002	0.0006	5.827	-0.0005	0.0016	-0.0017
2165	50	0.88	8.5	8.5	8	-0.0871	0.025	-0.5046	0.0006	0.2304	0.0056	-0.0003	8.044	0.0007	0.004	-0.0062
2165	50	0.57	9.5	18	16	-0.0096	0.0145	0.0028	0.0002	0.3409	0.0038	-0.0002	5.769	0.0003	0.0042	0.0006
2165	50	1.1	4.5	22.5	24											
2165	50	1	23.5	46	48	-0.0052	0.0437	-0.0705	0.0069	-0.5526	0.0009	0.0004	3.782	0	0.0006	-0.0016
2205	50	1.94	3	3	8											
2205	50	0.93	6.5	9.5	16											
2205	50	1.97	3	12.5	24											
2205	50	1.36	10.5	23	48	-0.02	0.0327	-0.1617	0.0051	-0.5774	0.0021	0.0003	4.541	-0.0002	-0.0039	-0.0014
2332	50	2.11	3.5	3.5	8											
2332	50	1.58	4	7.5	16											
2332	50	1.65	3	10.5	24											
2332	50	2.27	6.5	17	48											
2374	50	2.17	2	2	8											
2374	50	0.7	7	9	16	-0.0163	0.0087	-0.0266	-0.0013	0.0437	0.0022	-0.0002	3.728	-0.0006	-0.0005	-0.0022
2374	50	1.3	3	12	24											
2374	50	1.21	12.5	24.5	48	-0.0217	0.047	-0.0975	0.0011	-0.4475	0.0031	0.0004	4.891	0.0005	0.0057	-0.0007

Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	Cu µg/mL	Fe µg/mL	Hg µg/mL	I µg/mL	In µg/mL	K µg/mL	Li µg/mL	Mg µg/mL	Mn µg/mL	Mo µg/mL	Na µg/mL	Ni µg/mL
2078	50	1.81	3	3	8												
2078	50	0.75	7.5	10.5	16	0.0143	0.0152	0.0042	0.1988	-0.0436	325.1	0.016	5.286	0.0016	0.0551	487.8	0.0062
2078	50	1.13	4	14.5	24												
2078	50	0.99	14.5	29	48	0.0094	0.0158	-0.0015	0.4062	-0.1124	410.9	0.0233	0.5286	0.0006	0.0634	2948	-0.0135
2082	50	1.53	4	4	8												
2082	50	0.61	7.5	11.5	16	0.0467	0.0590	-0.0208	0.6156	-0.0071	356.9	0.0213	25.8	0.0116	0.0595	-4555	0.0088
2082	50	2.27	3	14.5	24												
2082	50	1.05	25.5	40	48	0.0583	0.0752	-0.007	-0.3599	-0.201	417.7	0.0278	15.59	0.0088	0.0765	689.9	0.0022
2092	50	1.42	4	4	8												
2092	50	0.55	9	13	16	0.0161	0.0174	-0.0164	2.191	0.1244	160	0.0141	10.82	0.0025	0.039	-2611	0.0044
2092	50	1.28	4	17	24												
2092	50	1.17	16.5	33.5	48	0.0365	0.0554	-0.0089	-1.753	-0.196	484.8	0.0344	0.9165	0.0011	0.0927	-7258	0.0139
2097	50	1.9	3.5	3.5	8												
2097	50	1.55	6.5	10	16												
2097	50	1.98	2	12	24												
2097	50	2.23	7.5	19.5	48	0.0507	0.11	-0.0084	-1.574	-0.4248	1040	0.0593	41.62	0.0275	0.1781	1886	0.0084
2155	50	1.15	6	6	8												
2155	50	0.37	26.5	32.5	16	0.0461	0.0585	-0.003	0.6626	0.1213	217.7	0.0139	13.8	0.0059	0.0372	-1916	0.019
2155	50	0.99	6.5	39	24	0.0539	0.1262	-0.0126	-9.315	-0.553	356.9	0.0222	0.8427	0.0026	0.0591	999.7	0.0026
2155	50	0.81	37.5	76.5	48	0.0786	0.0973	-0.0293	-0.1769	0.0977	324.5	0.0192	7.521	0.003	0.0584	2218	0.0078
2165	50	0.88	8.5	8.5	8	0.0556	0.1152	-0.0164	-0.8084	-0.1852	526.3	0.0289	19.82	0.0149	0.062	-4256	0.0113
2165	50	0.57	9.5	18	16	0.0569	0.0768	-0.0056	1.583	-0.0465	233.7	0.0164	10.71	0.0062	0.0576	396.1	0.0059
2165	50	1.1	4.5	22.5	24												
2165	50	1	23.5	46	48	0.0474	0.1087	-0.0216	0.4722	0.1146	371	0.0252	0.4157	0.0027	0.0714	2672	-0.0042
2205	50	1.94	3	3	8												
2205	50	0.93	6.5	9.5	16												
2205	50	1.97	3	12.5	24												
2205	50	1.36	10.5	23	48	0.034	0.0869	-0.0338	-1.675	0.0419	380.3	0.0244	0.5788	0	0.0661	1679	-0.0067
2332	50	2.11	3.5	3.5	8												
2332	50	1.58	4	7.5	16												
2332	50	1.65	3	10.5	24												
2332	50	2.27	6.5	17	48												
2374	50	2.17	2	2	8												
2374	50	0.7	7	9	16	0.0226	0.0174	-0.0223	0.8086	0.1508	181.9	0.0118	9.543	0.0069	0.0258	-1794	-0.0028
2374	50	1.3	3	12	24												
2374	50	1.21	12.5	24.5	48	0.0313	0.1569	-0.0093	-1.407	-0.0249	462.8	0.034	0.6663	0.004	0.1028	4057	-0.0013

Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	P µg/mL	Pb µg/mL	Pt µg/mL	S µg/mL	Sb µg/mL	Se µg/mL	Si µg/mL	Sn µg/mL	Sr µg/mL	Tl µg/mL	Ti µg/mL	V µg/mL	Zn µg/mL	C µg/mL
2078	50	1.81	3	3	8														
2078	50	0.75	7.5	10.5	16	78.85	-0.0008	-0.0019	121.1	0.0015	-0.0144	0.4165	-0.0309	0.0112	0	0.0317	0.0006	0.0217	1913
2078	50	1.13	4	14.5	24														
2078	50	0.99	14.5	29	48	91.01	-0.0076	0.0416	189.4	0.001	0.0503	0.3300	-0.1261	0.0135	-0.0003	0.0418	0.0014	0.0384	9122
2082	50	1.53	4	4	8														
2082	50	0.61	7.5	11.5	16	192	0.0086	-0.0242	199.7	0.0046	-0.0324	0.492	-0.1641	0.0126	-0.0018	0.0259	0.0012	0.0515	1761
2082	50	2.27	3	14.5	24														
2082	50	1.05	25.5	40	48	136	0.0117	0.0353	175	0.0045	0.0525	0.4624	-0.054	0.0236	-0.0007	-0.0148	-0.0003	0.0480	14426
2092	50	1.42	4	4	8														
2092	50	0.55	9	13	16	58.83	0.0014	-0.0125	71.80	-0.0076	-0.0064	0.3344	-0.179	0.0114	-0.0033	0.0802	0.0012	0.0407	2411
2092	50	1.28	4	17	24														
2092	50	1.17	16.5	33.5	48	113.6	0.0038	0.0180	208.4	-0.0067	0.0162	0.8027	-0.1828	0.0216	-0.0011	0.0246	0.0016	0.0650	12263
2097	50	1.9	3.5	3.5	8														
2097	50	1.55	6.5	10	16														
2097	50	1.98	2	12	24														
2097	50	2.23	7.5	19.5	48	287.2	0.0136	-0.0153	441.6	-0.0104	0.046	1.224	-0.187	0.0376	0.0004	0.0077	0.0014	0.0717	5236
2155	50	1.15	6	6	8														
2155	50	0.37	26.5	32.5	16	82.55	-0.0086	-0.0066	76.5	-0.0069	-0.0167	0.226	-0.187	0.0158	-0.0024	0.0609	0.0003	0.0732	2569
2155	50	0.99	6.5	39	24	84.2	-0.0092	-0.044	162	-0.0636	-0.0192	0.4871	-0.4642	0.0128	0	-0.8073	0	0.0891	3792
2155	50	0.81	37.5	76.5	48	87.35	-0.0107	0.0365	148.7	0.0102	-0.0051	0.4819	-0.0967	0.0164	-0.0021	0.0816	-0.0001	0.1678	4693
2165	50	0.88	8.5	8.5	8	180.8	0.0215	0.0414	146.1	-0.0076	0.0565	0.1748	-0.1567	0.0232	-0.0021	0.11	0.0005	0.0966	33254
2165	50	0.57	9.5	18	16	81.27	0.012	0.0180	116	0.0137	0.0288	0.4066	-0.0348	0.0156	0.0001	0.0642	0.0005	0.0635	4060
2165	50	1.1	4.5	22.5	24														
2165	50	1	23.5	46	48	89.76	0.001	0.0469	182.8	0.0043	0.0716	0.4523	-0.1215	0.0125	0.001	0.1921	0.0053	0.0796	10059
2205	50	1.94	3	3	8														
2205	50	0.93	6.5	9.5	16														
2205	50	1.97	3	12.5	24														
2205	50	1.36	10.5	23	48	135.4	-0.0041	0.0579	183.5	-0.0026	0.0615	0.4685	-0.1153	0.0163	0.0014	0.077	0.0007	0.0691	12327
2332	50	2.11	3.5	3.5	8														
2332	50	1.58	4	7.5	16														
2332	50	1.65	3	10.5	24														
2332	50	2.27	6.5	17	48														
2374	50	2.17	2	2	8														
2374	50	0.7	7	9	16	64.40	0.0046	-0.0343	89.89	-0.0147	-0.0432	0.1912	-0.1316	0.0091	-0.0016	0.0566	0.0018	0.0321	2059
2374	50	1.3	3	12	24														
2374	50	1.21	12.5	24.5	48	87.02	0.0015	0.0371	232.3	0.0072	0.0469	0.7089	-0.1182	0.0172	0.0003	0.0803	0.0011	0.0794	11927

Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	Ag µg/mL	Al µg/mL	As µg/mL	Au µg/mL	B µg/mL	Ba µg/mL	Be µg/mL	Ca µg/mL	Cd µg/mL	Co µg/mL	Cr µg/mL
2007	150	1.18	6.5	6.5	8	-0.0585	0.0052	-0.4443	-0.0006	0.2499	0.0045	-0.0004	4.731	0.0001	-0.001	-0.0059
2007	150	2.17	4	10.5	16											
2007	150	2.02	3	13.5	24											
2007	150	1.03	17.5	31	48	0.0242	0.0376	0.0284	0.0048	-0.4698	0.004	0.0005	6.672	0.0006	0.0005	0.001
2058	150	0.58	12	12	8	-0.0172	0.0147	-0.1092	-0.0015	0.1804	0.0016	-0.0002	6.009	-0.0001	0.0077	-0.0027
2058	150	0.27	20	32	16	-0.012	0.0113	-0.0283	-0.0024	0.0773	0.0046	-0.0002	8.655	-0.0004	0.0017	-0.0011
2058	150	0.7	5.5	37.5	24											
2058	150	0.76	40.5	78	48	-0.0155	0.0165	-0.0271	0.0011	0.2587	0.0027	-0.0002	5.708	0.0007	0.0035	-0.0021
2080	150	1.34	6	6	8											
2080	150	0.82	5.5	11.5	16											
2080	150	1.7	3	14.5	24											
2080	150	0.99	24.5	39	48	0.0009	0.0487	-0.0714	0.0037	-0.2399	0.0015	0.0004	3.233	-0.0004	-0.0021	0.0016
2105	150	0.66	7.5	7.5	8	-0.0499	0.0147	-0.2836	-0.0011	0.239	0.0006	-0.0005	2.097	-0.0004	-0.0002	-0.0047
2105	150	0.53	29.5	37	16	-0.0172	0.0139	-0.06	0.002	0.0359	0.0011	-0.0003	1.946	-0.0009	0.0042	-0.0016
2105	150	0.91	5.5	42.5	24											
2105	150	0.48	46.5	89	48	0.0009	0.0118	-0.0093	0.0029	-0.429	0.0025	0.0002	2.609	-0.0005	-0.007	0.0013
2144	150		0	0	8											
2144	150	1.47	6	6	16											
2144	150	2.41	1	7	24											
2144	150	1.64	11.5	18.5	48	-0.0184	0.0248	0.0326	0.0003	0.6985	0.0059	-0.0003	6.069	0.0012	0.0018	0.0012
2171	150	1.61	3	3	8											
2171	150	1.8	3	6	16											
2171	150	1.72	4.5	10.5	24											
2171	150	2.07	4	14.5	48											
2223	150	1.49	4.5	4.5	8											
2223	150	1.77	2	6.5	16											
2223	150	1.5	5.5	12	24											
2223	150	1.88	6	18	48											
2259	150	0.99	4.5	4.5	8											
2259	150	0.3	38.5	43	16	-0.0172	0.0104	-0.0275	-0.0006	0.0234	0.0023	-0.0002	3.708	0	-0.004	-0.0015
2259	150	0.65	7.5	50.5	24	-0.032	0.0316	0.0307	-0.0012	0.233	0.0031	-0.0002	9.102	0.0012	0.0013	-0.0009
2259	150	0.57	29.5	80	48	0.0017	0.0076	-0.0729	0.0048	-0.6269	-0.0002	0.0004	3.021	-0.0001	0.0029	-0.0015
2321	150	0.67	7.5	7.5	8	-0.0206	0.0121	-0.0975	-0.0004	0.1453	0.002	-0.0003	2.278	-0.0003	0.0027	-0.0026
2321	150	1.25	24.5	32	16	-0.0155	0.0121	-0.0975	0.002	0.0809	0.001	-0.0002	1.695	0	0.0064	-0.0016
2321	150	0.47	7.5	39.5	24	-0.0602	0.0104	-0.0975	0.0015	0.0547	0.0009	-0.0003	1.396	0.0007	0.0006	-0.006
2321	150	0.79	25.5	65	48	0.0174	0.0176	-0.0975	0.0062	-0.336	0.0025	0.0005	2.682	-0.0001	-0.0034	0.0006

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Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	Cu µg/mL	Fe µg/mL	Hg µg/mL	I µg/mL	In µg/mL	K µg/mL	Li µg/mL	Mg µg/mL	Mn µg/mL	Mo µg/mL	Na µg/mL	Ni µg/mL
2007	150	1.18	6.5	6.5	8	0.0385	0.0447	-0.0119	-1.412	-0.1731	504.2	0.0295	10.2	0.0039	0.057	-3941	-0.0073
2007	150	2.17	4	10.5	16												
2007	150	2.02	3	13.5	24												
2007	150	1.03	17.5	31	48	0.0235	0.1584	-0.0062	-0.2598	0.141	356.9	0.0281	30.53	0.0477	0.0711	1726	-0.0021
2058	150	0.58	12	12	8	0.0719	0.0331	-0.003	-0.3722	-0.0099	405.2	0.0215	12.97	0.0104	0.0567	-2516	0.0203
2058	150	0.27	20	32	16	0.0243	0.0224	-0.0149	1.397	0.0544	153.1	0.0104	10.44	0.007	0.0222	-3725	0.0032
2058	150	0.7	5.5	37.5	24												
2058	150	0.76	40.5	78	48	0.0391	0.0573	-0.003	1.942	-0.0629	367.1	0.0226	0.2615	0.0017	0.0568	-3268	0.0036
2080	150	1.34	6	6	8												
2080	150	0.82	5.5	11.5	16												
2080	150	1.7	3	14.5	24												
2080	150	0.99	24.5	39	48	0.0591	0.0913	0.0031	0.0184	-0.0833	413.8	0.0277	0.1729	0.0009	0.0606	2549	0.0034
2105	150	0.66	7.5	7.5	8	0.015	0.0336	-0.0104	-0.0505	-0.0716	403.8	0.0208	13.7	0.009	0.0534	-2159	0.0117
2105	150	0.53	29.5	37	16	0.0054	0.0144	-0.0193	1.496	0.1079	144.6	0.0084	10.13	0.0045	0.0194	-2824	-0.0057
2105	150	0.91	5.5	42.5	24												
2105	150	0.48	46.5	89	48	0.0187	0.0242	-0.0015	1.923	-0.0207	245.4	0.0164	0.732	0.0016	0.0419	1506	-0.003
2144	150		0	0	8												
2144	150	1.47	6	6	16												
2144	150	2.41	1	7	24												
2144	150	1.64	11.5	18.5	48	0.0426	0.1094	-0.0209	2.419	-0.1395	705.4	0.0439	50.58	0.0463	0.1421	963.5	-0.015
2171	150	1.61	3	3	8												
2171	150	1.8	3	6	16												
2171	150	1.72	4.5	10.5	24												
2171	150	2.07	4	14.5	48												
2223	150	1.49	4.5	4.5	8												
2223	150	1.77	2	6.5	16												
2223	150	1.5	5.5	12	24												
2223	150	1.88	6	18	48												
2259	150	0.99	4.5	4.5	8												
2259	150	0.3	38.5	43	16	0.0212	0.0168	-0.0268	2.058	0.1608	160.7	0.0114	9.581	0.0085	0.0251	-1774	0.0117
2259	150	0.65	7.5	50.5	24	0.0172	0.0586	-0.0111	1.636	-0.0272	246.7	0.0159	11.6	0.0065	0.0334	569.4	0.0007
2259	150	0.57	29.5	80	48	0.008	0.0311	-0.0185	-0.4638	0.1226	246.7	0.0167	0.2088	0	0.0434	1558	0.0143
2321	150	0.67	7.5	7.5	8	0.0199	0.0241	-0.0119	0.2801	0.0198	390.5	0.0172	9.047	0.0051	0.0462	-1177	0.0004
2321	150	1.25	24.5	32	16	0.0141	0.0201	-0.0238	2.676	0.116	151.7	0.0115	7.768	0.0042	0.0225	-2675	-0.0101
2321	150	0.47	7.5	39.5	24	0.0092	0.0312	-0.0104	0.4663	-0.0643	131.5	0.0103	5.79	0.0054	0.0178	-2143	-0.0077
2321	150	0.79	25.5	65	48	0.0197	0.0608	0.0015	0.0272	-0.0081	330.6	0.0204	2.249	0.0012	0.0589	1963	0.0008

Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	P µg/mL	Pb µg/mL	Pt µg/mL	S µg/mL	Sb µg/mL	Se µg/mL	Si µg/mL	Sn µg/mL	Sr µg/mL	Ti µg/mL	Tl µg/mL	V µg/mL	Zn µg/mL	C µg/mL
2007	150	1.18	6.5	6.5	8	178.7	0.0048	0.0386	108.2	-0.0102	0.0216	0.185	-0.1985	0.0165	-0.0025	-0.0566	0.0007	0.0436	28992
2007	150	2.17	4	10.5	16														
2007	150	2.02	3	13.5	24														
2007	150	1.03	17.5	31	48	134.2	-0.003	0.0641	189.5	0.0167	0.0256	0.7152	-0.1592	0.0184	-0.0005	0.1592	0.0008	0.0857	2142
2056	150	0.58	12	12	8	199.2	-0.0005	0.0246	131.1	-0.0062	-0.0216	0.3043	-0.1901	0.0139	-0.0018	0.0426	0.0007	0.0411	8460
2056	150	0.27	20	32	16	59.45	-0.0019	-0.0306	64.24	-0.0096	-0.0216	0.0962	-0.0872	0.0143	-0.002	0.0491	0.0014	0.0395	2121
2056	150	0.7	5.5	37.5	24														
2056	150	0.78	40.5	78	48	99.29	-0.001	-0.0065	175.2	-0.0069	0	0.4276	-0.0761	0.0196	-0.0018	0.0668	0.001	0.0464	4570
2080	150	1.34	6	6	8														
2080	150	0.82	5.5	11.5	16														
2080	150	1.7	3	14.5	24														
2080	150	0.99	24.5	39	48	65.48	-0.0015	0.0486	193.7	-0.0036	0.0262	0.446	-0.2107	0.0122	0.0001	0.0569	0.0006	0.0836	7860
2105	150	0.86	7.5	7.5	8	112.1	0.0006	-0.0074	119.5	-0.02	0	0.1455	-0.1801	0.0075	-0.0019	0.0592	0.0005	0.0292	19732
2105	150	0.53	29.5	37	16	43.37	-0.0038	-0.0229	51.59	0.0096	-0.0064	0.0917	-0.143	0.0085	-0.0026	0.0969	0.0002	0.0264	2356
2105	150	0.91	5.5	42.5	24														
2105	150	0.48	46.5	89	48	48.57	-0.0147	0.0401	95.56	-0.0036	0.0066	0.1003	-0.1024	0.0115	0.0008	0.0633	0.0011	0.0411	4045
2144	150		0	0	8														
2144	150	1.47	6	6	16														
2144	150	2.41	1	7	24														
2144	150	1.64	11.5	18.5	48	261.8	0.0075	-0.0377	316.1	-0.0039	0.046	1.22	0.0133	0.0296	-0.0004	0.0911	0.001	0.0726	4180
2171	150	1.61	3	3	8														
2171	150	1.8	3	6	16														
2171	150	1.72	4.5	10.5	24														
2171	150	2.07	4	14.5	48														
2223	150	1.49	4.5	4.5	8														
2223	150	1.77	2	6.5	16														
2223	150	1.5	5.5	12	24														
2223	150	1.86	6	18	48														
2259	150	0.99	4.5	4.5	8														
2259	150	0.3	38.5	43	16	56.16	-0.001	0.0103	59.73	-0.0174	-0.0432	0.1607	-0.0462	0.0082	-0.0026	0.0779	0.0013	0.0336	2086
2259	150	0.65	7.5	50.5	24	84.07	0.005	0.0146	154.2	0.0053	0.0395	0.5913	-0.0416	0.0186	-0.0007	0.067	-0.0002	0.0235	3356
2259	150	0.57	29.5	80	48	87.1	-0.0046	0.0662	104.7	0.0072	0.0256	0.5440	-0.1186	0.0079	-0.0006	0.0665	-0.0005	0.0251	4711
2321	150	0.67	7.5	7.5	8	102.3	0.0062	0.0355	121	-0.0023	-0.0216	0.1637	-0.0966	0.0062	-0.0023	0.0475	0.0014	0.0355	5878
2321	150	1.26	24.5	32	16	55.66	-0.0043	0.0037	58.16	-0.0082	-0.0216	0.0654	-0.1679	0.006	-0.0018	0.0851	0.002	0.0247	1920
2321	150	0.47	7.5	39.5	24	26.56	0.01	0.0867	80.72	-0.0065	-0.0378	0.2765	-0.1587	0.0053	-0.0016	0.0667	0.0026	0.0776	21410
2321	150	0.79	25.5	65	48	79.22	0.002	0.0496	148.5	0.0131	0.0419	0.4059	-0.0618	0.0111	0	0.0559	0.0012	0.0462	3620

Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	Ag µg/mL	Al µg/mL	As µg/mL	Au µg/mL	B µg/mL	Ba µg/mL	Be µg/mL	Ca µg/mL	Cd µg/mL	Co µg/mL	Cr µg/mL
2043	500	1.1	7.5	7.5	8	-0.0128	0.0198	0.0338	-0.0018	0.5498	0.0025	-0.0003	5.227	0.0002	0	-0.0005
2043	500	0.44	10.5	18	16	-0.0248	0.0265	-0.0085	0.0007	0.2051	0.0017	0	4.902	0.0003	-0.0057	-0.0007
2043	500	0.66	4	22	24											
2043	500	1.01	21.5	43.5	48	0.0052	0.0311	-0.0424	0.0027	-0.1707	0.0027	0.0005	4.417	0.001	-0.0013	0.0004
2114	500	2.03	3	3	8											
2114	500	1.03	7.5	10.5	16	0	0.0179	0.0256	-0.0018	0.5	0.0039	-0.0001	4.379	0.0011	-0.001	0.0006
2114	500	1.21	7	17.5	24											
2114	500	0.78	24.5	42	48	0.0138	0.021	0.0332	0.0052	-0.3683	0.0023	0.0006	2.685	-0.0001	0.0052	0.002
2138	500	0.99	7	7	8	-0.0731	0.0364	-0.5722	0.0017	0.2281	0.006	-0.0003	7.621	0.0016	0.0015	-0.0059
2138	500	0.88	7	14	16	-0.012	0.0113	-0.08	0.0007	0.2773	0.0088	-0.0002	10.9	-0.0003	0.0025	-0.0022
2138	500	0.8	4.5	18.5	24											
2138	500	0.96	15.5	34	48	-0.0043	0.0252	-0.06	0.0013	-0.459	0.0001	0.0004	7.465	0.0003	-0.0008	-0.0019
2147	500	1.09	3	3	8											
2147	500	0.89	7.5	10.5	16	-0.0616	0.0094	-0.2637	-0.0016	0.4193	0.0021	-0.0004	5.139	0.0006	-0.0034	-0.0019
2147	500	1.06	3	13.5	24											
2147	500	2.19	7.5	21	48	0.0122	0.0202	0.0405	-0.0009	-0.0292	0.0034	0.0005	4.004	0.0021	-0.0013	-0.0021
2225	500	1.74	4	4	8											
2225	500	1.66	5	9	16											
2225	500	0.86	7.5	16.5	24	-0.0232	0.0236	0.0204	0.0008	0.316	0.0026	-0.0002	3.048	-0.0002	-0.0006	0.0001
2225	500	1.44	7.5	24	48	-0.0096	0.0190	-0.014	0.0005	-0.3076	0.0022	0.0004	3.253	-0.0001	0.0031	-0.0011
2261	500	2.2	2	2	8											
2261	500	1.24	3	5	16											
2261	500	1.11	3	8	24											
2261	500	2.01	4.5	12.5	48											
2355	500	1.99	4	4	8											
2355	500	0.54	8.5	12.5	16	-0.0043	0.0139	-0.0207	0.0035	0.1945	0.0016	-0.0002	5.7	0.0001	0.0027	-0.0012
2355	500	1.34	4	16.5	24											
2355	500	1.23	7.5	24	48	0.0165	0.0269	-0.0101	0.0006	0.4585	0.0006	-0.0004	5.107	0.0009	0.0046	-0.0021
2364	500	1.6	3	3	8											
2364	500	0.62	8	11	16	-0.1016	0.0129	-0.6059	-0.0025	0.3077	0.0025	-0.0003	5.958	0.0002	0.0046	-0.0041
2364	500	0.79	6	17	24											
2364	500	1.49	9.5	26.5	48	0.0062	0.0312	-0.0299	-0.0006	0.6732	0.0039	-0.0002	[illegible]	0.0015	-0.0007	-0.0027
2365	500	1.28	4.5	4.5	8											
2365	500	0.73	7.5	12	16	-0.0017	0.0182	0.0083	0.0016	0.4085	0.0021	-0.0003	6.357	-0.0002	0.004	-0.0015
2365	500	1.17	3	15	24											
2365	500	1	10	25	48	-0.0146	0.0243	-0.0605	-0.002	0.6115	0.0037	-0.0002	3.841	0.0018	0.006	-0.0031

Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	Cu µg/mL	Fe µg/mL	Hg µg/mL	I µg/mL	In µg/mL	K µg/mL	Li µg/mL	Mg µg/mL	Mn µg/mL	Mo µg/mL	Na µg/mL	Ni µg/mL
2043	500	1.1	7.5	7.5	8	0.028	0.0412	-0.0014	0.8625	-0.049	687.6	0.0331	17.42	0.0114	0.1028	241.3	0.0117
2043	500	0.44	10.5	18	16	0.0096	0.0162	0.0084	1.981	-0.0107	185.5	0.0117	6.198	0.006	0.0227	336	-0.0139
2043	500	0.66	4	22	24												
2043	500	1.01	21.5	43.5	48	0.0356	0.0718	0.0077	0.3478	-0.1038	468.4	0.032	0.4771	0.005	0.0909	3054	-0.0097
2114	500	2.03	3	3	8												
2114	500	1.03	7.5	10.5	16	0.0569	0.0667	0.007	1.228	-0.2576	369.6	0.0309	17.63	0.0221	0.0874	1104	0.0114
2114	500	1.21	7	17.5	24												
2114	500	0.78	24.5	42	48	0.0292	0.0628	-0.0015	0.4693	0.013	298.1	0.0203	11.46	0.0105	0.053	1535	-0.0165
2138	500	0.99	7	7	8	0.0491	0.1341	-0.0178	-0.9834	-0.1485	474.3	0.026	10.73	0.0136	0.0603	-3151	-0.0109
2138	500	0.88	7	14	16	0.0615	0.1033	-0.0178	0.6336	-0.0277	386.8	0.0285	26.92	0.0193	0.0663	-6074	0.0066
2138	500	0.8	4.5	18.5	24												
2138	500	0.96	15.5	34	48	0.0569	0.0642	-0.0231	-1.638	0.0235	416.7	0.0291	0.7029	0.0016	0.0721	3250	-0.0025
2147	500	1.09	3	3	8												
2147	500	0.89	7.5	10.5	16	0.0279	0.0234	-0.0111	0.260	-0.2485	489.1	0.034	8.197	0.0049	0.0907	1192	-0.0015
2147	500	1.06	3	13.5	24												
2147	500	2.19	7.5	21	48	0.074	0.0537	-0.0247	-1.826	-0.2424	986.9	0.0676	1.84	0.0012	0.1853	6251	-0.008
2225	500	1.74	4	4	8												
2225	500	1.66	5	9	16												
2225	500	0.86	7.5	16.5	24	0.024	0.0385	-0.0084	0.7397	-0.0678	279.4	0.021	14.49	0.013	0.0491	467.4	-0.0033
2225	500	1.44	7.5	24	48	0.0382	0.0907	-0.0093	-1.067	-0.0918	823.6	0.0407	6.25	0.006	0.1333	4422	-0.0135
2261	500	2.2	2	2	8												
2261	500	1.24	3	5	16												
2261	500	1.11	3	8	24												
2261	500	2.01	4.5	12.5	48												
2355	500	1.99	4	4	8												
2355	500	0.54	8.5	12.5	16	0.0348	0.0486	-0.0312	2.381	0.115	349.2	0.0229	17.9	0.0175	0.057	-3762	0.0069
2355	500	1.34	4	16.5	24												
2355	500	1.23	7.5	24	48	0.0782	0.1284	0	-0.9814	-0.1602	522.9	0.0362	0.9259	0.0051	0.1021	-9022	-0.0069
2364	500	1.6	3	3	8												
2364	500	0.62	8	11	16	0.0263	0.0368	-0.0084	0.0312	-0.2059	295.4	0.0205	13.6	0.013	0.0494	478.8	-0.0106
2364	500	0.79	6	17	24												
2364	500	1.49	9.5	26.5	48	0.0109	0.0949	-0.0015	-0.3651	-0.2388	888.9	0.0475	2.914	0.0037	0.1357	-9999	-0.0105
2365	500	1.28	4.5	4.5	8												
2365	500	0.73	7.5	12	16	0.028	0.0375	-0.0178	1.074	-0.0779	481	0.0335	27.6	0.0121	0.0571	-9571	0.0129
2365	500	1.17	3	15	24												
2365	500	1	10	25	48	0.0444	0.0788	-0.0059	-1.843	-0.283	749.2	0.0505	0.312	0.002	0.1324	-9999	0.0028

Rat ID	CS2 (ppm)	Creatinine mg/mL	Time Urine Volume (mL)	Total Urine Volume (mL)	Time (hr)	P µg/mL	Pb µg/mL	Pt µg/mL	S µg/mL	Sb µg/mL	Se µg/mL	Si µg/mL	Sn µg/mL	Sr µg/mL	Ti µg/mL	Tl µg/mL	V µg/mL	Zn µg/mL	C µg/mL
2043	500	1.1	7.5	7.5	8	135.8	0.0255	0.0209	229.4	0.0125	0.0258	0.7873	-0.04	0.0148	0	0.0257	0.0004	0.0375	2330
2043	500	0.44	10.5	18	16	64.59	0.008	0.0008	59.69	0.0024	-0.0384	0.2167	-0.0429	0.0066	0	0.0364	0	0.0155	361.1
2043	500	0.66	4	22	24														
2043	500	1.01	21.5	43.5	48	102.3	-0.066	0.0809	169.3	0.0043	0.0576	0.4517	-0.0912	0.0139	0.0004	0.0004	0.0075	0.0666	7773
2114	500	2.03	3	3	8														
2114	500	1.03	7.5	10.5	16	187.1	0.0165	-0.006	188.6	0.0006	0	0.883	-0.0888	0.0164	0.0001	0.0222	-0.0001	0.0494	3726
2114	500	1.21	7	17.5	24														
2114	500	0.78	24.5	42	48	86.52	0.001	0.0426	150.3	0.0165	0.0062	0.4653	-0.1086	0.0089	0.0008	0.0862	0.0006	0.0319	3461
2138	500	0.99	7	7	8	161.1	0.0124	0.0384	158.9	-0.0092	0.0422	1.386	-0.2211	0.0209	-0.0018	0.09	0.0008	0.0986	27425
2138	500	0.86	7	14	16	177.7	-0.0038	-0.0302	158.2	0.0026	-0.0324	3.7121	-0.1667	0.0238	-0.0022	0.071	0.001	0.0642	5038
2138	500	0.6	4.5	18.5	24														
2138	500	0.96	15.5	34	48	127	-0.0071	0.0287	181.3	0	0.0409	0.5365	-0.1098	0.0157	-0.0006	0.1106	0.0003	0.0667	8909
2147	500	1.09	3	3	8														
2147	500	0.89	7.5	10.5	16	146.3	0.0169	-0.023	165	-0.0125	0.024	3.1872	-0.1129	0.0138	-0.0009	0.0686	-0.0013	0.0282	18862
2147	500	1.06	3	13.5	24														
2147	500	2.19	7.5	21	48	341.4	0.003	0.0378	443.6	0.0003	0.1239	0.7871	-0.1916	0.0233	0	0.0684	0.0047	0.0965	8866
2225	500	1.74	4	4	8														
2225	500	1.66	5	9	16														
2225	500	0.86	7.5	16.5	24	80.38	0.0029	0.019	111.3	0.0003	0	0.3084	-0.081	0.0125	0.0004	0.0405	-0.0018	0.043	1869
2225	500	1.44	7.5	24	48	186.5	0.003	0.0671	289.4	0.0043	0.1329	0.9316	-0.2692	0.0167	-0.0008	0.0444	0.0031	0.0628	6208
2261	500	2.2	2	2	8														
2261	500	1.24	3	5	16														
2261	500	1.11	3	8	24														
2261	500	2.01	4.5	12.5	48														
2355	500	1.99	4	4	8														
2355	500	0.54	8.5	12.5	16	138.4	0	-0.0341	130.7	-0.001	-0.0432	0.3734	-0.1427	0.0166	-0.0018	0.0874	0.0072	0.047	1488
2355	500	1.34	4	16.5	24														
2355	500	1.23	7.5	24	48	139.5	0.0126	-0.0233	225.7	-0.0079	0.0054	0.9153	-0.143	0.0188	-0.0004	0.0455	0.0036	0.0936	4215
2364	500	1.6	3	3	8														
2364	500	0.62	8	11	16	118.5	0.0113	0.0309	100.4	-0.005	0.1152	0.3107	-0.1067	0.0153	-0.0019	0.029	0	0.0168	46763
2364	500	0.79	6	17	24														
2364	500	1.49	9.5	26.5	48	184.6	-0.0019	-0.0087	318.7	-0.0226	0.0378	0.6216	-0.0787	0.0203	0	0.0858	0.0021	0.0661	7117
2365	500	1.28	4.5	4.5	8														
2365	500	0.73	7.5	12	16	183	-0.0172	0.0311	179.6	-0.0016	-0.0064	0.3802	-0.2166	0.02	-0.0022	0.0799	0.0022	0.051	1908
2365	500	1.17	3	15	24														
2365	500	1	10	25	48	192.9	0.011	0.0213	313.3	-0.0157	0.0649	0.606	-0.1386	0.0193	-0.0006	0.052	0.0006	0.0676	9862

7.2 Appendix B ---- Data tables with < LQL values replaced and adjusted for creatinine

Rat ID #	Time (hours) after exp	CS2 exposure	Creatinine mg/ml	Time Urine (ml)	Cumulative urine (ml)	Al µg/mg creat	B µg/mg creat	Ca µg/mg creat	Co µg/mg creat	Cu µg/mg creat	Fe µg/mg creat
2061	8	0	0.96	19.5	19.5	0.011563	0.567187	6.80208	0.004167	0.068542	0.106458
2040	8	0	0.91	7.5	7.5	0.02	0.206813	11.1429	0.002198	0.030769	0.044286
2200	16	0	0.7	7.5	12	0.016143	0.421714	12.5129	0.008571	0.038571	0.047143
2381	16	0	0.43	9.5	14	0.032326	0.234186	7.3186	0.014419	0.033488	0.061395
2061	16	0	0.66	9	28.5	0.013182	0.111212	5.23182	0.000758	0.040455	0.069849
2040	16	0	0.49	15	22.5	0.001837	0.484898	16.6082	0.00102	0.019592	0.050408
2392	16	0	1.09	6.5	12	0.026606	0.529266	14.7706	0.002477	0.099266	0.023211
2193	16	0	0.87	7.5	14	0.015747	0.543563	12.2759	0.006782	0.104943	0.127241
2164	48	0	1.71	7.5	22.5	0.019942	0.396491	1.56667	0.002222	0.025556	0.041988
2381	48	0	0.96	20.5	38.5	0.012604	0.434479	5.99687	0.012396	0.02	0.115625
2299	48	0	1.44	7.5	19	0.005833	0.017361	3.78681	0.000347	0.023125	0.052431
2200	48	0	1.56	9.5	25.5	0.015064	0.016026	3.90385	0.000321	0.01641	0.039551
2193	48	0	1.62	7.5	24.5	0.009877	0.015432	3.23642	0.001111	0.059877	0.082593
2392	48	0	1.48	9.5	24.5	0.006824	0.016892	3.32095	0.006892	0.023311	0.045405
2061	48	0	1.64	8.5	41.5	0.020976	0.015244	2.80244	0.004634	0.06311	0.111707
2040	48	0	0.82	20.5	46.5	0.030732	0.030488	5.57073	0.00061	0.01561	0.040366
2165	8	50	0.88	8.5	8.5	0.029546	0.261818	9.14091	0.004545	0.063182	0.130909
2165	16	50	0.57	9.5	18	0.025439	0.59807	10.1211	0.007368	0.099825	0.134737
2082	16	50	0.61	7.5	11.5	0.004262	0.321311	4.83934	0.002787	0.074918	0.098197
2374	16	50	0.7	7	9	0.012429	0.062429	5.32286	0.000714	0.032286	0.024857
2092	16	50	0.55	9	13	0.034727	0.268364	4.75273	0.007636	0.029273	0.031636
2155	16	50	0.37	26.5	32.5	0.021081	0.278649	12.727	0.012703	0.124595	0.158108
2078	16	50	0.75	7.5	10.5	0.017067	0.380133	3.892	0.000667	0.019067	0.020267
2155	24	50	0.99	6.5	39	0.005051	0.324545	5.62222	0.000505	0.054444	0.127475
2374	48	50	1.21	12.5	24.5	0.038843	0.020661	3.82727	0.004711	0.025868	0.131322
2082	48	50	1.05	25.5	40	0.021143	0.362667	5.82	0.000476	0.055524	0.071619
2205	48	50	1.36	10.5	23	0.024044	0.018382	3.33897	0.000368	0.025	0.065368
2165	48	50	1	23.5	46	0.0437	0.025	3.762	0.0005	0.0474	0.1087
2078	48	50	0.99	14.5	29	0.011919	0.025253	3.52828	0.002626	0.009495	0.018788
2097	48	50	2.23	7.5	19.5	0.009955	0.465471	3.46009	0.000448	0.022735	0.049327
2155	48	50	0.81	37.5	76.5	0.017654	0.030864	7.19383	0.001975	0.097037	0.120123
2092	48	50	1.17	16.5	33.5	0.015556	0.441197	3.39744	0.002735	0.031197	0.04735

Rat ID #	Time (hours) after exp	CS2 exposure	Creatinine mg/ml	Time Urine (ml)	Cumulative urine (ml)	I µg/mg creat	K µg/mg creat	Li µg/mg creat	Mg µg/mg creat	Mn µg/mg creat	Mo µg/mg creat
2061	8	0	0.96	19.5	19.5	0.335417	608.125	0.035313	20.9479	0.01	0.10875
2040	8	0	0.91	7.5	7.5	0.935165	354.615	0.024506	20.0659	0.017692	0.048571
2200	16	0	0.7	7.5	12	2.29143	568	0.041857	28.3714	0.021	0.112429
2381	16	0	0.43	9.5	14	3.36977	476.512	0.040233	43.8837	0.023488	0.08093
2061	16	0	0.66	9	28.5	2.08788	227.727	0.018333	20.2121	0.009848	0.040455
2040	16	0	0.49	15	22.5	2.60204	606.122	0.040612	30.7959	0.013674	0.106122
2392	16	0	1.09	6.5	12	0.863578	502.385	0.041009	29.0275	0.002385	0.10211
2193	16	0	0.87	7.5	14	0.057471	618.506	0.040575	19.8276	0.006552	0.10931
2164	48	0	1.71	7.5	22.5	0.02924	389.181	0.026608	0.169415	0.000292	0.074269
2381	48	0	0.96	20.5	38.5	1.28229	457.5	0.030521	34.3438	0.030208	0.077292
2299	48	0	1.44	7.5	19	0.034722	511.597	0.032917	0.262569	0.000347	0.104236
2200	48	0	1.56	9.5	25.5	0.032051	375.449	0.023974	0.094487	0.000321	0.071346
2193	48	0	1.62	7.5	24.5	0.030864	418.519	0.026111	0.220926	0.000309	0.08821
2392	48	0	1.48	9.5	24.5	0.033784	420.068	0.028987	0.164189	0.000338	0.085878
2061	48	0	1.64	6.5	41.5	0.030488	396.707	0.024329	1.24756	0.00128	0.0775
2040	48	0	0.82	20.5	46.5	0.060976	436.951	0.028781	0.552805	0.00061	0.085732
2165	8	50	0.88	8.5	8.5	0.056818	598.068	0.032841	22.5227	0.016932	0.070455
2165	16	50	0.57	9.5	18	2.77719	410	0.032281	18.7895	0.009123	0.101053
2082	16	50	0.61	7.5	11.5	1.00951	585.082	0.034918	42.2951	0.019016	0.097541
2374	16	50	0.7	7	9	1.15086	231.286	0.016857	13.3471	0.008429	0.036857
2092	16	50	0.55	9	13	3.98364	327.273	0.025636	19.6727	0.004545	0.070909
2155	16	50	0.37	26.5	32.5	1.79081	588.378	0.037568	37.2973	0.015946	0.100541
2078	16	50	0.75	7.5	10.5	0.2624	433.467	0.025333	7.048	0.002133	0.073467
2155	24	50	0.99	6.5	39	0.050505	360.505	0.022424	0.851212	0.002626	0.059697
2374	48	50	1.21	12.5	24.5	0.041322	382.479	0.028099	0.54405	0.002479	0.084959
2082	48	50	1.05	25.5	40	0.047619	397.81	0.026286	14.8476	0.00819	0.072952
2205	48	50	1.36	10.5	23	0.036765	279.632	0.017941	0.425441	0.000368	0.048603
2165	48	50	1	23.5	46	0.4722	371	0.0252	0.4137	0.0027	0.0714
2078	48	50	0.99	14.5	29	0.412323	415.051	0.023535	0.528788	0.000505	0.06404
2097	48	50	2.23	7.5	19.5	0.022422	466.368	0.030852	18.6637	0.012332	0.078969
2155	48	50	0.81	37.5	76.5	0.061728	400.617	0.023704	9.28519	0.003704	0.072099
2092	48	50	1.17	16.5	33.5	0.042735	414.359	0.029402	0.270513	0.00094	0.079231

Rat ID #	Time (hours) after exp	CS2 exposure	Creatinine mg/ml	Time Urine (ml)	Cumulative urine (ml)	Na µg/mg creat	P µg/mg creat	Pt µg/mg creat	S µg/mg creat	Se µg/mg creat	Si µg/mg creat
2061	8	0	0.96	19.5	19.5	157.292	153.646	0.007396	173.438	0.015	0.424271
2040	8	0	0.91	7.5	7.5	68.7802	113.736	0.001209	138.022	0.005495	0.21
2200	16	0	0.7	7.5	12	397.857	189.286	0.000714	226.571	0.007143	0.466571
2381	16	0	0.43	9.5	14	395.116	169.698	0.001163	212.93	0.011628	1.01744
2061	16	0	0.66	9	28.5	207.424	122.879	0.000758	93.7121	0.007576	0.197879
2040	16	0	0.49	15	22.5	311.224	164	0.00102	201.837	0.010204	0.416735
2392	16	0	1.09	6.5	12	391.009	202.936	0.014312	196.606	0.057248	0.82156
2193	16	0	0.87	7.5	14	237.701	182.299	0.000575	220.575	0.005747	0.791149
2164	48	0	1.71	7.5	22.5	218.713	99.5322	0.020994	132.281	0.002924	0.461053
2381	48	0	0.96	20.5	38.5	202.813	135.521	0.000521	203.75	0.005208	0.819792
2299	48	0	1.44	7.5	19	253.542	120.486	0.037778	206.042	0.046181	0.532569
2200	48	0	1.56	9.5	25.5	171.09	102.628	0.031795	172.436	0.039295	0.475192
2193	48	0	1.62	7.5	24.5	172.16	146.049	0.014815	208.765	0.072593	0.716667
2392	48	0	1.48	9.5	24.5	218.784	109.932	0.042162	172.095	0.044932	0.6325
2061	48	0	1.64	8.5	41.5	140.732	119.085	0.03689	190.244	0.01561	0.5975
2040	48	0	0.82	20.5	46.5	186.098	81.4634	0.054756	163.659	0.070244	0.412927
2165	8	50	0.88	8.5	8.5	188.182	216.591	0.047046	165.114	0.098296	0.198636
2165	16	50	0.57	9.5	18	201.579	142.579	0.032105	201.754	0.050526	0.713333
2082	16	50	0.61	7.5	11.5	267.213	265.574	0.00082	315.082	0.008197	0.740984
2374	16	50	0.7	7	9	96.4857	77.7857	0.000714	85.5571	0.007143	0.273143
2092	16	50	0.55	9	13	180.455	108.418	0.000909	130.6	0.009091	0.608
2155	16	50	0.37	26.5	32.5	188.838	223.108	0.001351	206.757	0.013514	0.616216
2078	16	50	0.75	7.5	10.5	178.8	105.173	0.000667	161.467	0.006667	0.555733
2155	24	50	0.99	6.5	39	308.384	64.8485	0.000505	163.636	0.005051	0.48697
2374	48	50	1.21	12.5	24.5	244.545	71.9174	0.030661	167.19	0.033802	0.586694
2082	48	50	1.05	25.5	40	208.571	129.524	0.024095	166.667	0.050286	0.45981
2205	48	50	1.36	10.5	23	100.809	99.5588	0.0425	142.279	0.045074	0.367279
2165	48	50	1	23.5	46	194.9	89.79	0.0409	162.8	0.0716	0.4523
2078	48	50	0.99	14.5	29	211.212	91.9293	0.04202	168.081	0.063434	0.333535
2097	48	50	2.23	7.5	19.5	255.516	119.821	0.000224	198.027	0.021525	0.593722
2155	48	50	0.81	37.5	76.5	199.877	107.84	0.043951	183.58	0.006173	0.607284
2092	48	50	1.17	16.5	33.5	212.137	96.1538	0.015897	176.41	0.013846	0.686066

Rat ID #	Time (hours) after exp	CS2 exposure	Creatinine mg/ml	Time Urine (ml)	Cumulative urine (ml)	Sr µg/mg creat	Tl µg/mg creat	V µg/mg creat	Zn µg/mg creat	C µg/mg creat
2061	8	0	0.96	19.5	19.5	0.021667	0.042813	0.000521	0.107604	2594.79
2040	8	0	0.91	7.5	7.5	0.025824	0.06044	0.002198	0.061099	14641.8
2200	16	0	0.7	7.5	12	0.027286	0.133714	0.002143	0.054	7658.57
2381	16	0	0.43	9.5	14	0.025116	0.242791	0.004419	0.06	2962.79
2061	16	0	0.66	9	28.5	0.013485	0.037879	0.000758	0.059091	5165.15
2040	16	0	0.49	15	22.5	0.032041	0.05102	0.00102	0.07102	6479.59
2392	16	0	1.09	6.5	12	0.037523	0.022936	0.000459	0.052569	19831.2
2193	16	0	0.87	7.5	14	0.038966	0.028736	-0.00023	0.108621	13831
2164	48	0	1.71	7.5	22.5	0.010702	0.049298	0.000292	0.030468	6803.51
2381	48	0	0.96	20.5	38.5	0.020417	0.026042	0.002083	0.050833	2160.42
2299	48	0	1.44	7.5	19	0.015347	0.017361	0.001181	0.038056	3841.67
2200	48	0	1.56	9.5	25.5	0.009936	0.085	0.002436	0.03109	9056.41
2193	48	0	1.62	7.5	24.5	0.020988	0.015432	0.001358	0.113457	8222.22
2392	48	0	1.48	9.5	24.5	0.010743	0.065135	0.001892	0.042432	10801.4
2061	48	0	1.64	8.5	41.5	0.01189	0.041342	0.001037	0.078232	5913.41
2040	48	0	0.82	20.5	46.5	0.016829	0.087439	0.002561	0.043902	11095.1
2165	8	50	0.88	8.5	8.5	0.026364	0.125	0.000568	0.112045	37788.6
2165	16	50	0.57	9.5	18	0.027368	0.112632	0.000877	0.111404	7105.26
2082	16	50	0.61	7.5	11.5	0.020656	0.042459	0.001967	0.084426	2886.89
2374	16	50	0.7	7	9	0.013	0.079429	0.002571	0.045857	2941.43
2092	16	50	0.55	9	13	0.020727	0.145818	0.002182	0.074	4363.64
2155	16	50	0.37	26.5	32.5	0.042703	0.164595	0.000811	0.195135	6943.24
2078	16	50	0.75	7.5	10.5	0.014933	0.042267	0.0008	0.028933	2017.33
2155	24	50	0.99	6.5	39	0.012929	0.025253	0.000505	0.09	3630.3
2374	48	50	1.21	12.5	24.5	0.014215	0.066364	0.000909	0.062314	9857.02
2082	48	50	1.05	25.5	40	0.022667	0.02381	0.000476	0.047524	13799
2205	48	50	1.36	10.5	23	0.011985	0.056618	0.000515	0.050809	9063.97
2165	48	50	1	23.5	46	0.0125	0.1921	0.0053	0.0799	10059
2078	48	50	0.99	14.5	29	0.012626	0.041919	0.001414	0.035758	8205.05
2097	48	50	2.23	7.5	19.5	0.016861	0.003453	0.000628	0.032153	2347.98
2155	48	50	0.81	37.5	76.5	0.020247	0.100741	0.000617	0.133086	6040.74
2092	48	50	1.17	16.5	33.5	0.018462	0.021026	0.001538	0.056325	10498.3

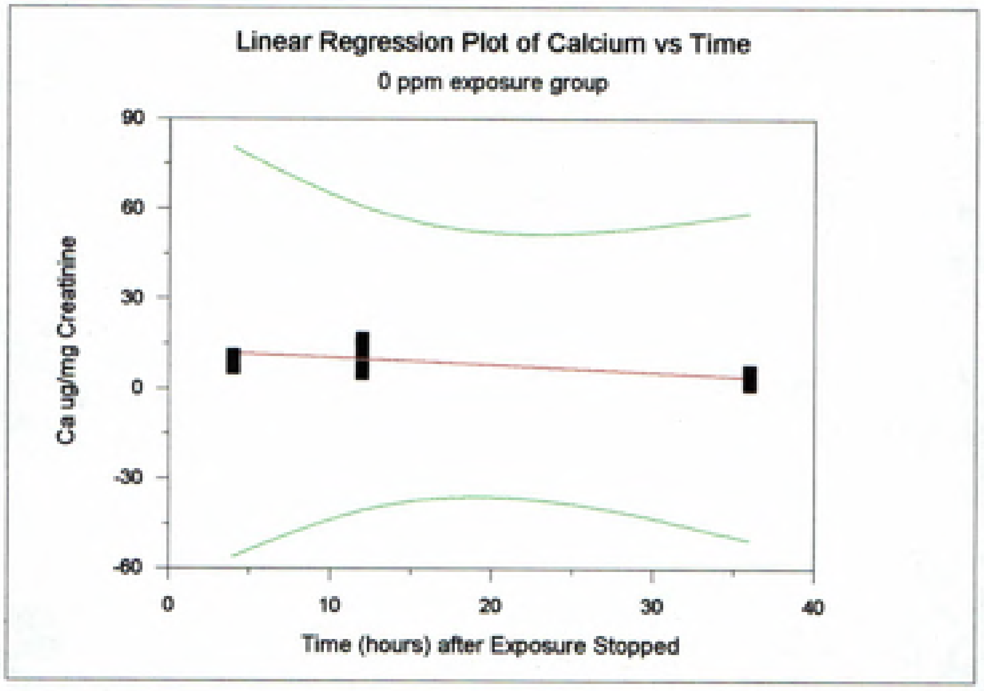
Rat ID #	Time (hours) after exp	CS2 exposure	Creatinine mg/ml	Time Urine (ml)	Cumulative urine (ml)	Al µg/mg creat	B µg/mg creat	Ca µg/mg creat	Co µg/mg creat	Cu µg/mg creat	Fe µg/mg creat	I µg/mg creat
2007	8	150	1.18	6.5	6.5	0.004407	0.21178	3.50085	0.000424	0.030932	0.037881	0.042373
2321	8	150	0.67	7.5	7.5	0.01806	0.216866	3.4	0.00403	0.029702	0.03597	0.41806
2105	8	150	0.66	7.5	7.5	0.022273	0.362121	3.17727	0.000758	0.022727	0.050909	0.075758
2058	8	150	0.58	12	12	0.025345	0.311034	10.3603	0.013276	0.123966	0.057069	0.086207
2259	16	150	0.3	38.5	43	0.034667	0.083333	12.36	0.001667	0.070667	0.055333	6.85333
2105	16	150	0.53	29.5	37	0.026226	0.04717	3.6717	0.007925	0.010189	0.02717	2.82264
2058	16	150	0.27	20	32	0.041852	0.286296	24.563	0.006296	0.09	0.082963	5.17407
2321	16	150	1.25	24.5	32	0.00968	0.04872	2.132	0.00512	0.01128	0.01608	2.3024
2259	24	150	0.65	7.5	50.5	0.048615	0.358462	14.0031	0.002	0.026462	0.090154	2.52154
2321	24	150	0.47	7.5	39.5	0.022128	0.116383	2.97021	0.001064	0.020213	0.066383	0.99
2259	48	150	0.57	29.5	80	0.013333	0.04386	5.3	0.005088	0.014035	0.054561	0.087719
2080	48	150	0.99	24.5	39	0.049192	0.025253	3.26566	0.000505	0.059697	0.092222	0.050505
2321	48	150	0.79	25.5	65	0.022279	0.031646	3.39494	0.000633	0.024937	0.076962	0.063291
2105	48	150	0.48	46.5	89	0.024583	0.052083	5.85208	0.001042	0.041042	0.050417	4.00625
2058	48	150	0.76	40.5	78	0.021711	0.353553	7.51053	0.004605	0.03829	0.049079	2.42368
2144	48	150	1.64	11.5	18.5	0.015122	0.425793	3.7128	0.000793	0.025976	0.066707	1.475
2007	48	150	1.03	17.5	31	0.036699	0.024272	5.5068	0.000485	0.022816	0.153786	0.048544
2138	8	500	0.99	7	7	0.036768	0.230404	7.69798	0.001515	0.049596	0.135455	0.050505
2043	8	500	1.1	7.5	7.5	0.017818	0.499818	4.75182	0.000455	0.025455	0.037455	0.893182
2043	16	500	0.44	10.5	18	0.060227	0.466136	11.2091	0.001136	0.021818	0.036818	4.45682
2147	16	500	0.89	7.5	10.5	0.010562	0.471124	3.52697	0.000562	0.031348	0.026292	0.22809
2364	16	500	0.62	8	11	0.020645	0.49629	9.60645	0.007742	0.042419	0.059355	0.050323
2114	16	500	1.03	7.5	10.5	0.017379	0.485437	4.15437	0.000485	0.057185	0.088117	1.19029
2365	16	500	0.73	7.5	12	0.024932	0.559589	8.70137	0.005479	0.038356	0.05137	1.47123
2138	16	500	0.88	7	14	0.012841	0.315114	12.3864	0.002841	0.069886	0.117386	0.947273
2355	16	500	0.54	8.5	12.5	0.025741	0.360185	10.5556	0.005	0.064444	0.09	4.40926
2225	24	500	0.86	7.5	16.5	0.027791	0.367442	3.54419	0.000581	0.027907	0.044884	0.860116
2114	48	500	0.78	24.5	42	0.026923	0.032051	3.45513	0.006667	0.037436	0.105897	0.627308
2355	48	500	1.23	7.5	24	0.02187	0.372764	4.15203	0.003659	0.063577	0.10439	0.04065
2043	48	500	1.01	21.5	43.5	0.030792	0.024753	4.37327	0.000495	0.035248	0.070792	0.245149
2364	48	500	1.49	9.5	26.5	0.02094	0.451812	3.51342	0.000336	0.042886	0.05698	0.033557
2225	48	500	1.44	7.5	24	0.013403	0.017361	2.25903	0.002153	0.026528	0.062986	0.034722
2138	48	500	0.96	15.5	34	0.02625	0.026042	7.77604	0.000521	0.069688	0.098125	0.052083
2365	48	500	1	10	25	0.0243	0.6115	3.641	0.006	0.0444	0.0766	0.05
2147	48	500	2.19	7.5	21	0.009224	0.011416	1.82831	0.000228	0.03379	0.024521	0.022831

Rat ID #	Time (hours) after exp	CS2 exposure	Creatinine mg/ml	Time Urine (ml)	Cumulative urine (ml)	K µg/mg creat	Li µg/mg creat	Mg µg/mg creat	Mn µg/mg creat	Mo µg/mg creat	Na µg/mg creat	P µg/mg creat
2007	8	150	1.18	6.5	6.5	444.237	0.025	8.64407	0.003305	0.048305	125.169	151.441
2321	8	150	0.67	7.5	7.5	567.91	0.025672	13.503	0.007612	0.068955	65.1343	152.687
2105	8	150	0.66	7.5	7.5	611.818	0.031515	20.7576	0.013636	0.080909	122.5	169.848
2058	8	150	0.58	12	12	698.621	0.037069	22.1897	0.017931	0.096035	161.879	186.724
2259	16	150	0.3	38.5	43	535.667	0.036	31.9367	0.021667	0.083667	223.067	183.867
2105	16	150	0.53	29.5	37	272.83	0.017736	19.1132	0.008491	0.036604	195.283	81.8302
2058	16	150	0.27	20	32	567.037	0.038519	38.6667	0.025926	0.082222	503.704	242.444
2321	16	150	1.25	24.5	32	121.36	0.0092	6.2128	0.00336	0.018	82.56	44.544
2259	24	150	0.65	7.5	50.5	378	0.029077	18.3077	0.01	0.051385	265.385	129.338
2321	24	150	0.47	7.5	39.5	279.787	0.021915	12.3191	0.011489	0.037872	175.83	60.766
2259	48	150	0.57	29.5	80	432.807	0.029298	0.368316	0.000877	0.07614	217.368	100.175
2080	48	150	0.99	24.5	39	417.98	0.02798	0.174545	0.000909	0.081616	182.323	88.3434
2321	48	150	0.79	25.5	65	418.481	0.025823	2.84684	0.001519	0.074557	173.165	99.0127
2105	48	150	0.48	46.5	89	511.25	0.034167	1.52708	0.00375	0.087292	221.042	97.0208
2058	48	150	0.76	40.5	78	483.026	0.029605	0.344079	0.002237	0.088026	150.921	130.645
2144	48	150	1.64	11.5	18.5	430.122	0.026768	30.8415	0.029451	0.087256	176.585	159.634
2007	48	150	1.03	17.5	31	346.505	0.022427	29.6408	0.046311	0.069029	119.32	130.291
2138	8	500	0.99	7	7	479.091	0.028283	10.8384	0.013939	0.060909	126.768	162.727
2043	8	500	1.1	7.5	7.5	625.364	0.030091	15.8364	0.010364	0.093455	64.1727	123.455
2043	16	500	0.44	10.5	18	421.591	0.026591	20.9045	0.018182	0.051591	227.5	146.795
2147	16	500	0.89	7.5	10.5	560.787	0.038202	10.3337	0.005506	0.099663	416.742	164.382
2364	16	500	0.62	8	11	476.452	0.037903	21.9355	0.020968	0.079677	252.903	178.226
2114	16	500	1.03	7.5	10.5	553.01	0.03	17.1165	0.021456	0.084854	309.612	181.65
2365	16	500	0.73	7.5	12	658.904	0.04589	37.8082	0.016575	0.119315	480.137	250.685
2138	16	500	0.88	7	14	416.818	0.032386	32.8636	0.020796	0.075341	258.636	201.932
2355	16	500	0.54	8.5	12.5	646.667	0.042407	33.1481	0.032407	0.105556	254.63	250.741
2225	24	500	0.86	7.5	16.5	324.884	0.024419	16.8488	0.015116	0.057093	295.233	93.4651
2114	48	500	0.78	24.5	42	382.179	0.026026	14.6923	0.020897	0.067949	136.538	110.923
2355	48	500	1.23	7.5	24	425.122	0.029431	0.671463	0.004146	0.083008	244.309	113.415
2043	48	500	1.01	21.5	43.5	493.465	0.031683	0.472376	0.00297	0.09	213.762	101.287
2364	48	500	1.49	9.5	26.5	462.349	0.031879	1.9557	0.002483	0.091074	240.537	124.027
2225	48	500	1.44	7.5	24	433.056	0.028264	5.72917	0.005556	0.092569	217.986	128.819
2138	48	500	0.96	15.5	34	434.083	0.030313	0.732083	0.001563	0.075104	251.354	132.292
2365	48	500	1	10	25	749.2	0.0508	0.312	0.002	0.1324	365.2	192.9
2147	48	500	2.19	7.5	21	450.639	0.026301	0.748858	0.000548	0.084612	199.087	155.89

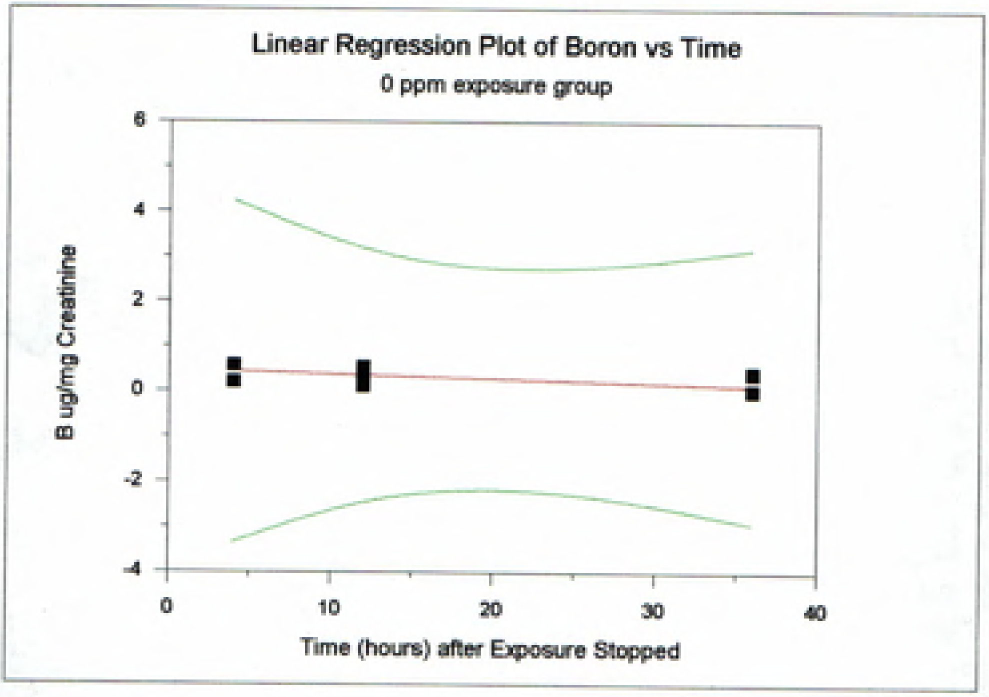
Rat ID #	Time (hours) after exp	CS2 exposure	Creatinine mg/ml	Time Urine (ml)	Cumulative urine (ml)	Pt µg/mg creat	S µg/mg creat	Se µg/mg creat	Si µg/mg creat	Sr µg/mg creat
2007	8	150	1.18	6.5	6.5	0.033559	134.068	0.018305	0.140339	0.013983
2321	8	150	0.67	7.5	7.5	0.03806	180.597	0.007463	0.274179	0.012239
2105	8	150	0.66	7.5	7.5	0.000758	181.061	0.007576	0.220455	0.011364
2058	8	150	0.58	12	12	0.060172	226.034	0.008621	0.524655	0.023966
2259	16	150	0.3	38.5	43	0.034333	199.1	0.016667	0.635667	0.030667
2105	16	150	0.53	29.5	37	0.000943	97.3396	0.009434	0.154151	0.012264
2058	16	150	0.27	20	32	0.001852	237.926	0.018519	0.33037	0.052963
2321	16	150	1.25	24.5	32	0.00256	47.32	0.004	0.07632	0.0048
2259	24	150	0.65	7.5	50.5	0.022308	237.231	0.051692	1.04815	0.028923
2321	24	150	0.47	7.5	39.5	0.020638	129.191	0.010638	0.482128	0.011277
2259	48	150	0.57	29.5	80	0.151228	183.684	0.044912	0.954912	0.013333
2080	48	150	0.99	24.5	39	0.069293	165.354	0.026465	0.450505	0.012323
2321	48	150	0.79	25.5	65	0.062785	188.354	0.053038	0.591013	0.014051
2105	48	150	0.48	46.5	89	0.083542	199.688	0.07625	0.415208	0.023958
2058	48	150	0.76	40.5	78	0.000658	230.526	0.006579	0.562632	0.020526
2144	48	150	1.64	11.5	16.5	0.000305	192.744	0.029268	0.743902	0.017439
2007	48	150	1.03	17.5	31	0.062233	183.981	0.024854	0.694369	0.017864
2138	8	500	0.99	7	7	0.038788	158.485	0.043636	0.311111	0.021111
2043	8	500	1.1	7.5	7.5	0.018909	208.545	0.026182	0.715727	0.013455
2043	16	500	0.44	10.5	18	0.001136	133.386	0.011364	0.495909	0.021591
2147	16	500	0.89	7.5	10.5	0.000562	189.888	0.026966	0.221573	0.015281
2364	16	500	0.62	8	11	0.049839	161.935	0.185806	0.339839	0.024677
2114	16	500	1.03	7.5	10.5	0.000485	183.107	0.004854	0.672816	0.014952
2365	16	500	0.73	7.5	12	0.042603	246.438	0.006849	0.493425	0.027397
2138	16	500	0.88	7	14	0.000568	177.5	0.005682	0.809205	0.026705
2355	16	500	0.54	8.5	12.5	0.000926	222.593	0.009259	0.691481	0.030741
2225	24	500	0.86	7.5	16.5	0.022093	129.419	0.005814	0.356279	0.014535
2114	48	500	0.78	24.5	42	0.054615	192.692	0.00641	0.596538	0.01141
2355	48	500	1.23	7.5	24	0.000407	183.496	0.004065	0.665285	0.015366
2043	48	500	1.01	21.5	43.5	0.060297	167.624	0.05703	0.447228	0.013663
2364	48	500	1.49	9.5	26.5	0.000336	212.55	0.025369	0.403758	0.013624
2225	48	500	1.44	7.5	24	0.046597	187.083	0.092292	0.64	0.011597
2138	48	500	0.96	15.5	34	0.030938	199.479	0.042604	0.561979	0.016354
2365	48	500	1	10	25	0.0213	312.3	0.0649	0.605	0.0193
2147	48	500	2.19	7.5	21	0.017306	202.557	0.060685	0.345708	0.010639

Rat ID #	Time (hours) after exp	CS2 exposure	Creatinine mg/ml	Time Urine (ml)	Cumulative urine (ml)	Tl µg/mg creat	V µg/mg creat	Zn µg/mg creat	C µg/mg creat
2007	8	150	1.18	6.5	6.5	0.002119	0.000424	0.036864	24569.5
2321	8	150	0.67	7.5	7.5	0.003731	0.00209	0.052985	10411.9
2105	8	150	0.66	7.5	7.5	0.089697	0.000758	0.044242	29972.7
2058	8	150	0.58	12	12	0.00431	0.000862	0.070862	14586.2
2259	16	150	0.3	38.5	43	0.259667	0.004333	0.112667	6783.33
2105	16	150	0.53	29.5	37	0.18283	0.000943	0.049811	4443.4
2058	16	150	0.27	20	32	0.009259	0.005185	0.146296	7855.56
2321	16	150	1.25	24.5	32	0.06888	0.0016	0.01976	1240
2259	24	150	0.65	7.5	50.5	0.133846	0.000769	0.035077	5107.69
2321	24	150	0.47	7.5	39.5	0.188723	0.005532	0.048723	45574.5
2259	48	150	0.57	29.5	80	0.151754	0.000877	0.044035	8284.91
2080	48	150	0.99	24.5	39	0.057475	0.000505	0.084647	8048.48
2321	48	150	0.79	25.5	65	0.108734	0.001519	0.058481	4586.08
2105	48	150	0.48	46.5	89	0.131667	0.002292	0.085625	8427.08
2058	48	150	0.76	40.5	78	0.087895	0.001316	0.061053	6021.05
2144	48	150	1.64	11.5	18.5	0.055549	0.00061	0.04439	2548.78
2007	48	150	1.03	17.5	31	0.154563	0.000485	0.063786	2080.58
2138	8	500	0.99	7	7	0.090909	0.000505	0.100808	37803
2043	8	500	1.1	7.5	7.5	0.022727	0.000455	0.034091	2120
2043	16	500	0.44	10.5	18	0.056818	0.001136	0.042046	2184.32
2147	16	500	0.89	7.5	10.5	0.065843	0.000562	0.031685	20844.9
2364	16	500	0.62	8	11	0.040323	0.000806	0.027097	73795.2
2114	16	500	1.03	7.5	10.5	0.024272	0.000485	0.047961	3611.65
2365	16	500	0.73	7.5	12	0.109452	0.003014	0.069863	2613.7
2138	16	500	0.88	7	14	0.080682	0.001136	0.095682	5711.36
2355	16	500	0.54	8.5	12.5	0.161852	0.004074	0.087037	2774.07
2225	24	500	0.86	7.5	16.5	0.02907	0.000581	0.05	2193.02
2114	48	500	0.78	24.5	42	0.109231	0.000641	0.040897	3155.13
2355	48	500	1.23	7.5	24	0.020325	0.002846	0.076342	3508.13
2043	48	500	1.01	21.5	43.5	0.092475	0.002277	0.088139	7300
2364	48	500	1.49	9.5	26.5	0.04396	0.001409	0.037651	4776.51
2225	48	500	1.44	7.5	24	0.017361	0.002153	0.044375	5698.61
2138	48	500	0.96	15.5	34	0.115208	0.000521	0.090313	8967.71
2365	48	500	1	10	25	0.052	0.0005	0.0676	9902
2147	48	500	2.19	7.5	21	0.031233	0.002146	0.045571	2551.6

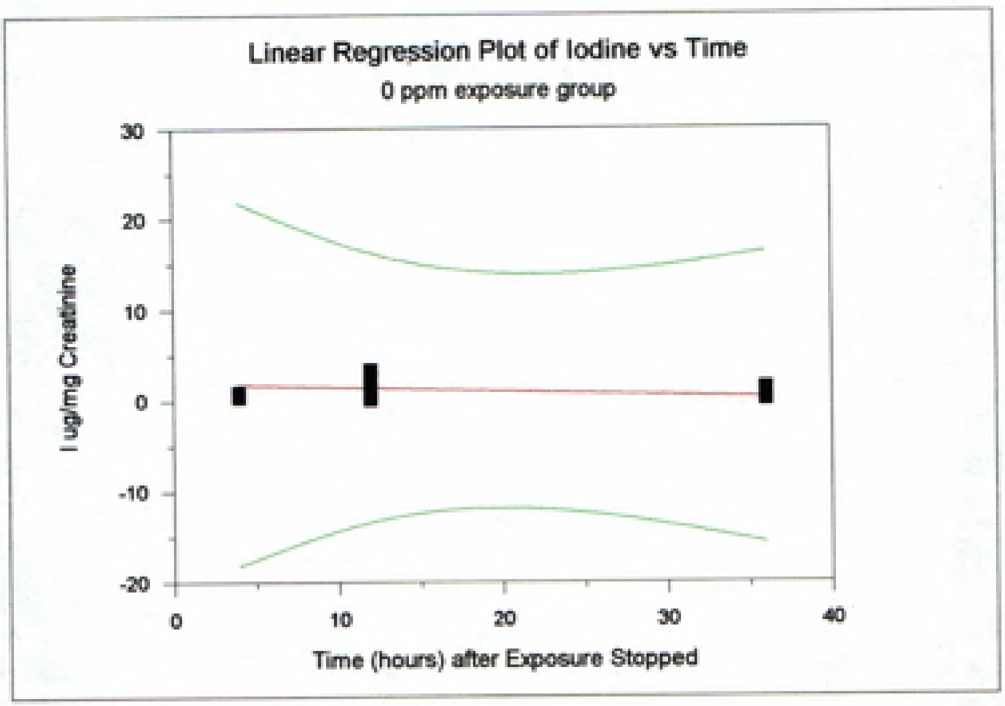
7.3 Appendix C ---- Linear regression plots of metals (μg/mg) vs time

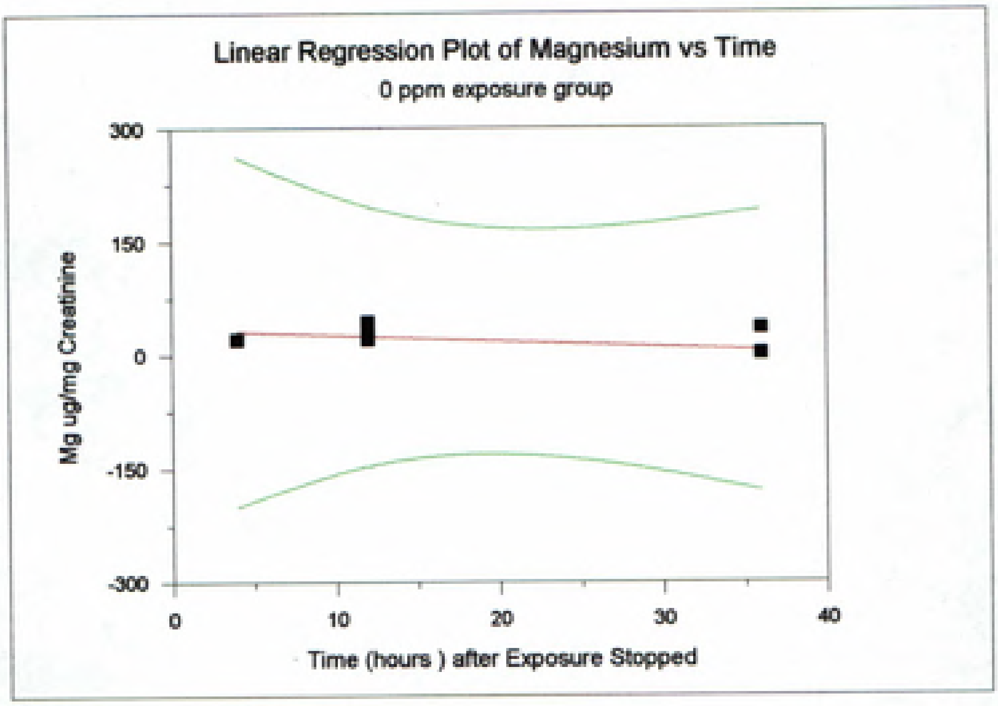


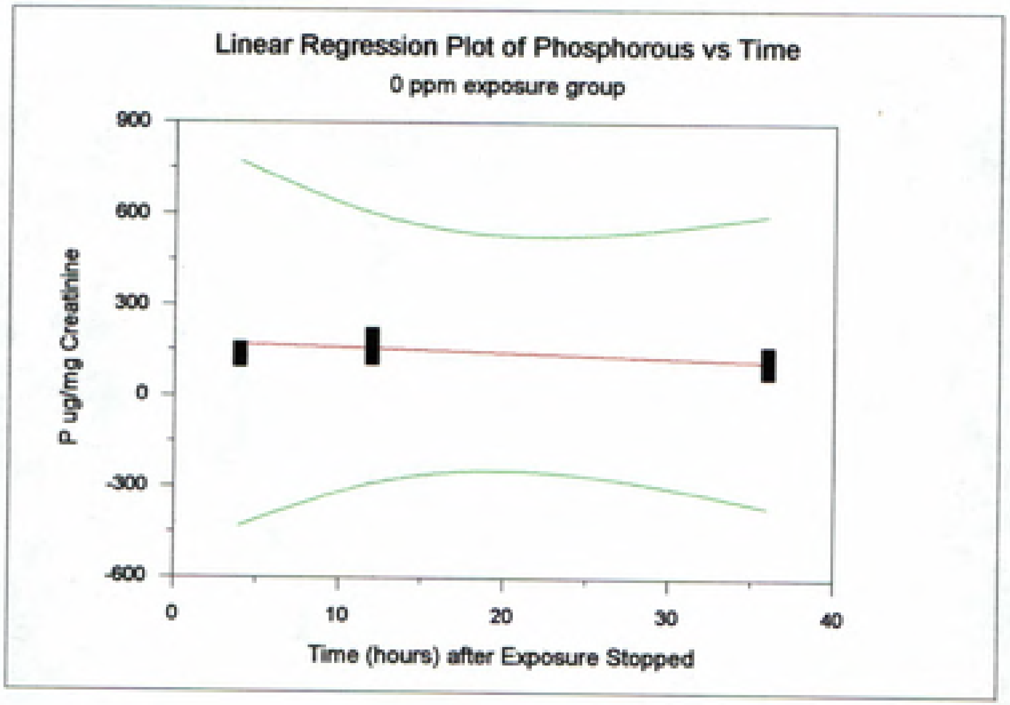
Linear Regression Plot of Calcium vs Time
0 ppm exposure group
90
60
30
0
-30
-60
Ca ug/mg Creatinine
0
10
20
30
40
Time (hours) after Exposure Stopped

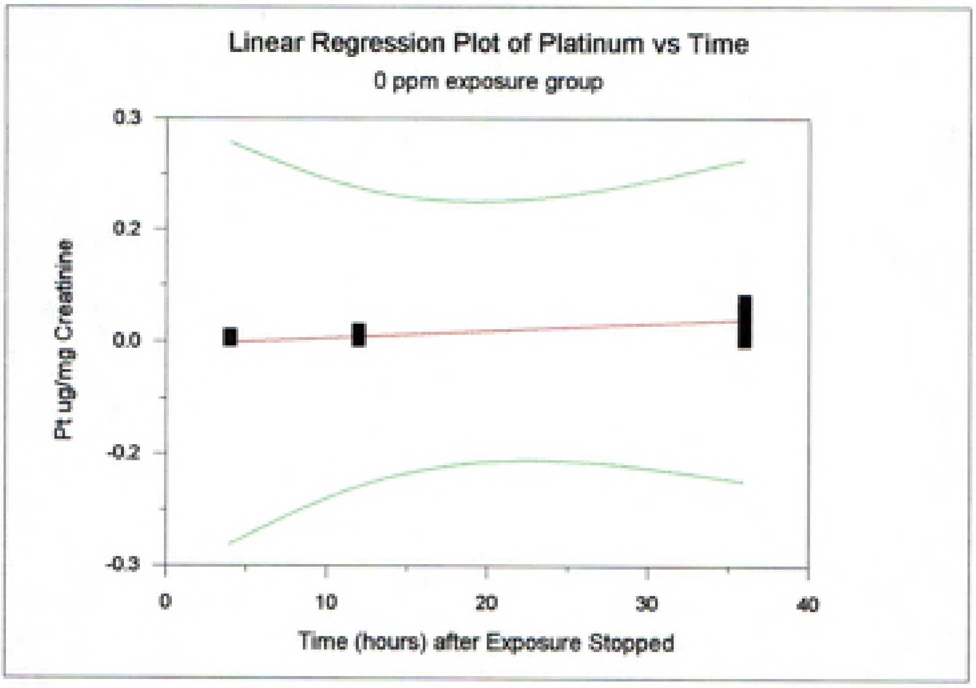


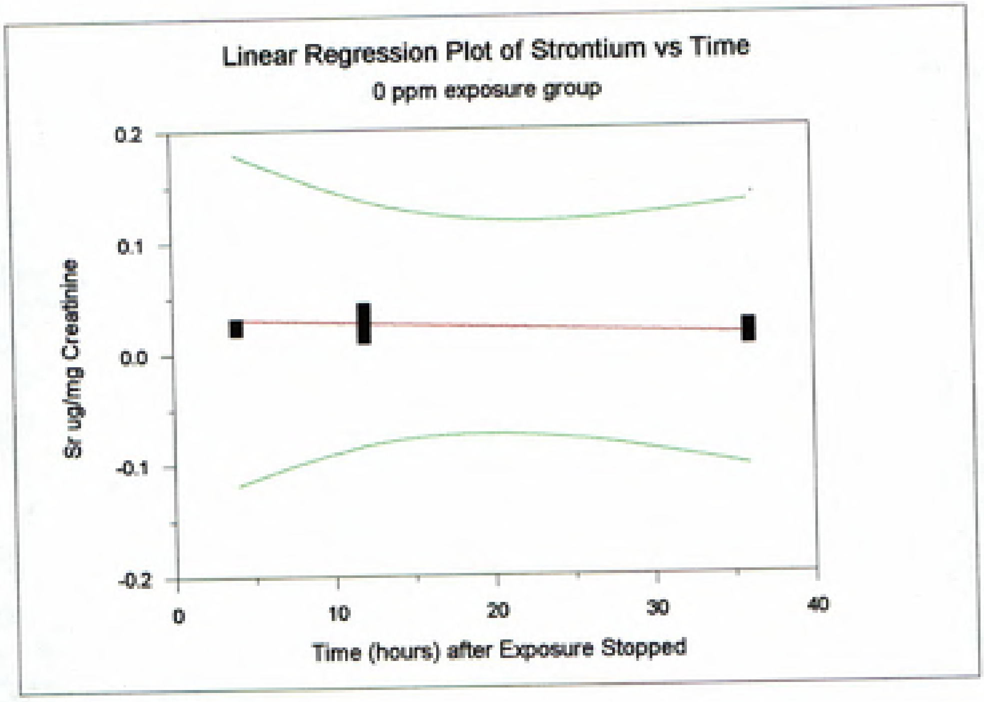
Linear Regression Plot of Boron vs Time
0 ppm exposure group
B ug/mg Creatinine
Time (hours) after Exposure Stopped
6
4
2
0
-2
-4
0
10
20
30
40

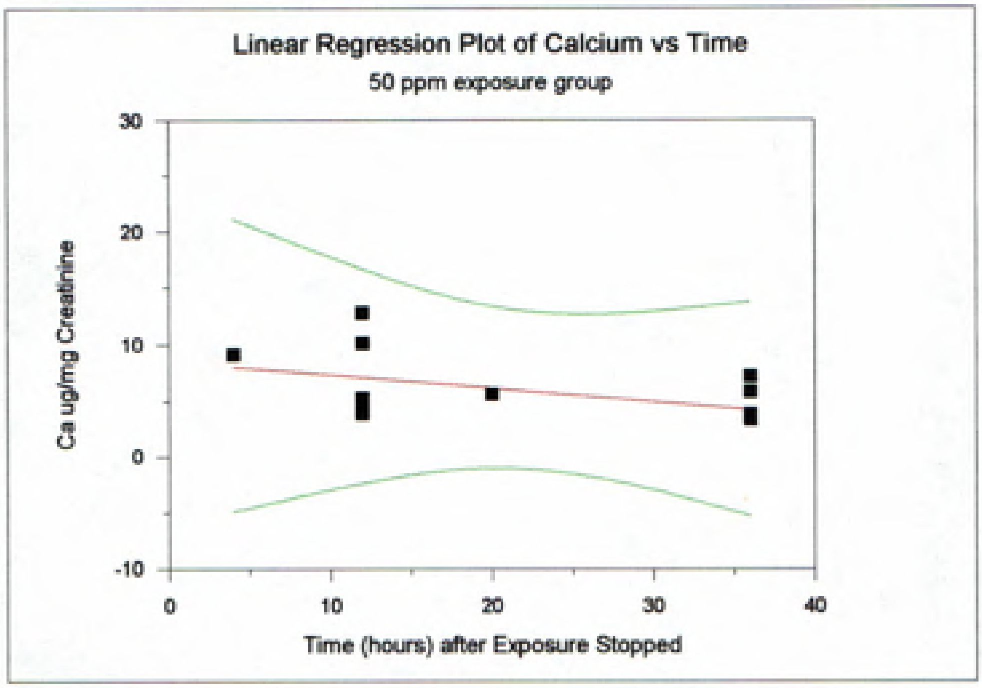

Linear Regression Plot of Iodine vs Time
0 ppm exposure group
I ug/mg Creatinine
30
20
10
0
-10
-20
0
10
20
30
40
Time (hours) after Exposure Stopped

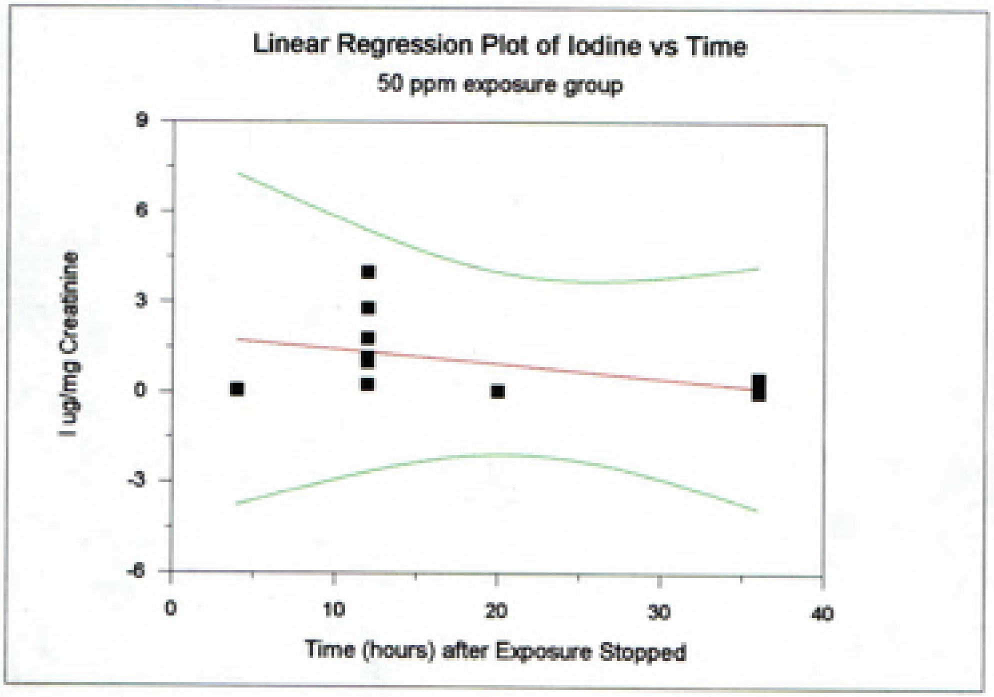

Linear Regression Plot of Magnesium vs Time
0 ppm exposure group
300
150
0
-150
-300
Mg ug/mg Creatinine
0
10
20
30
40
Time (hours) after Exposure Stopped

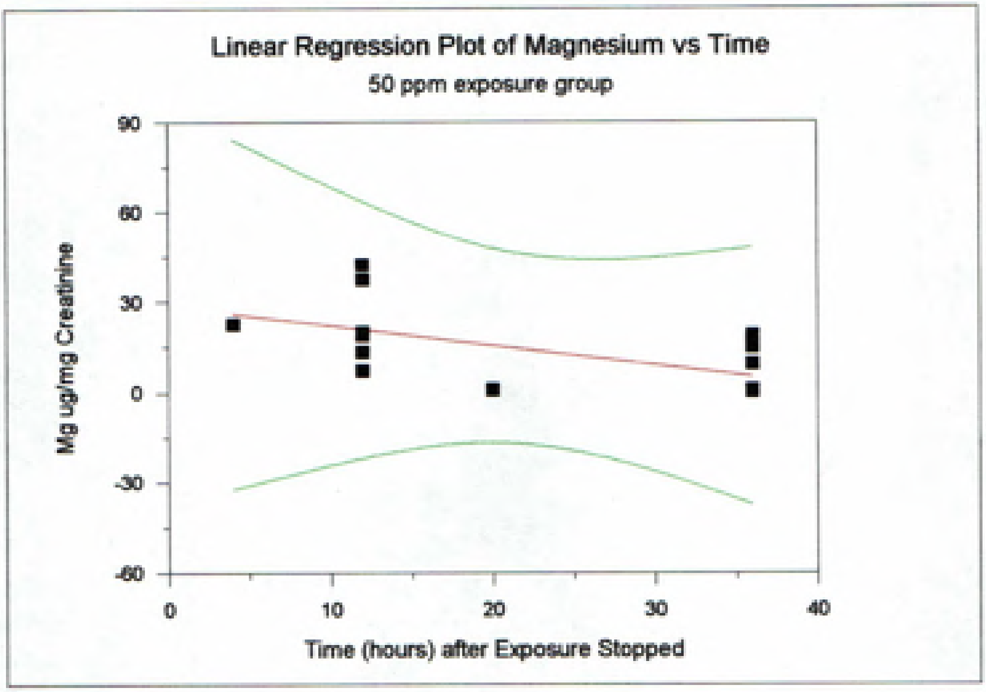

Linear Regression Plot of Phosphorous vs Time
0 ppm exposure group
P ug/mg Creatinine
900
600
300
0
-300
-600
0
10
20
30
40
Time (hours) after Exposure Stopped


Linear Regression Plot of Platinum vs Time
0 ppm exposure group
0.3
0.2
0.0
-0.2
-0.3
Pt ug/mg Creatinine
0
10
20
30
40
Time (hours) after Exposure Stopped

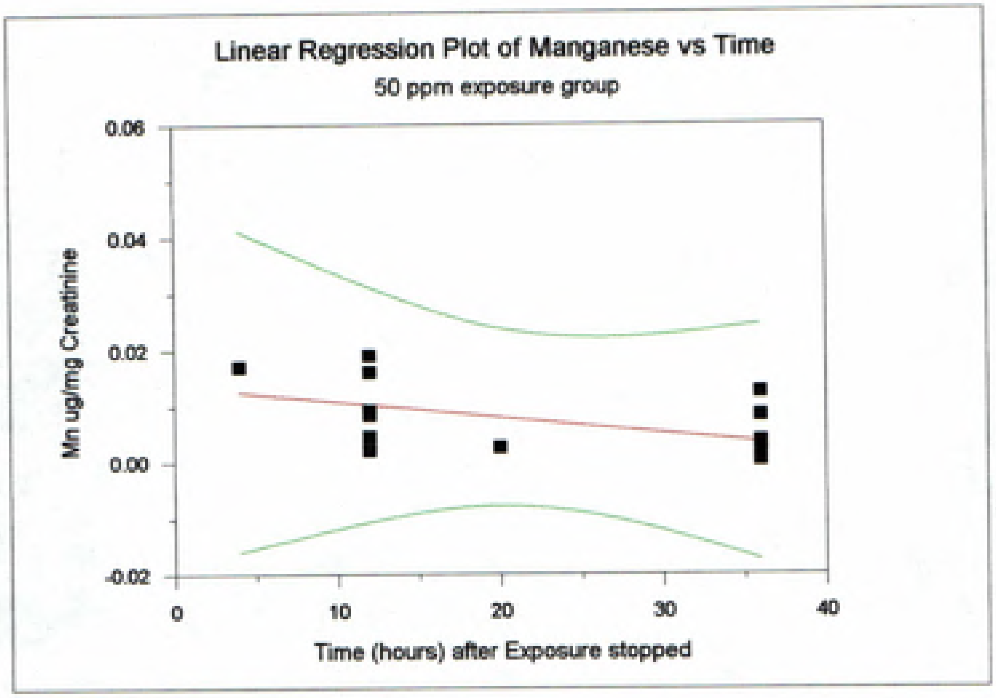

Linear Regression Plot of Strontium vs Time
0 ppm exposure group
Sr ug/mg Creatinine
0.2
0.1
0.0
-0.1
-0.2
0
10
20
30
40
Time (hours) after Exposure Stopped

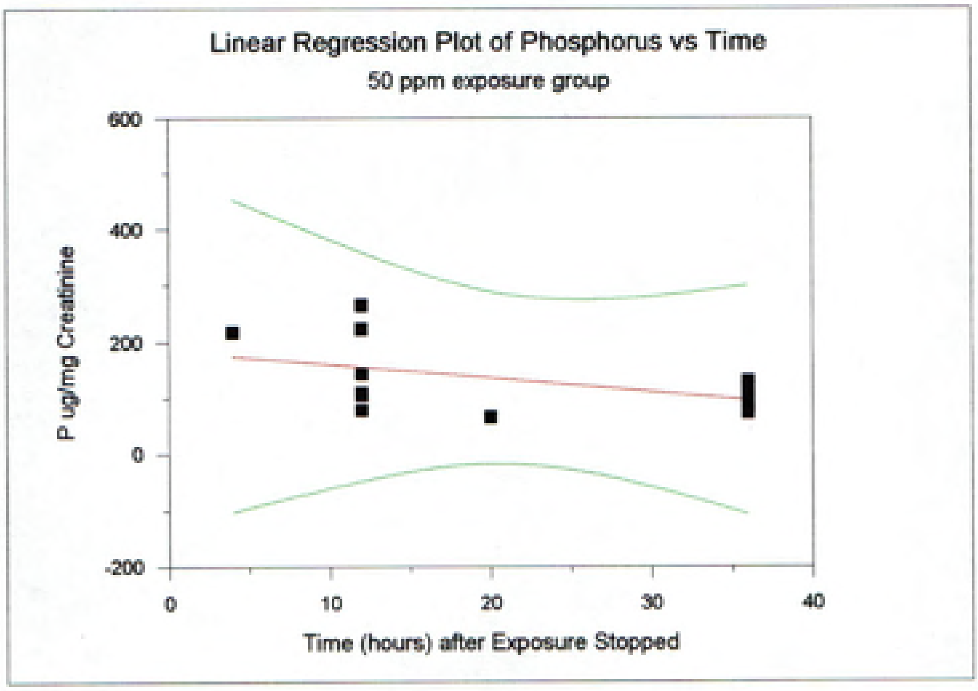

Linear Regression Plot of Calcium vs Time
50 ppm exposure group
Ca ug/mg Creatinine
Time (hours) after Exposure Stopped
30
20
10
0
-10
0
10
20
30
40

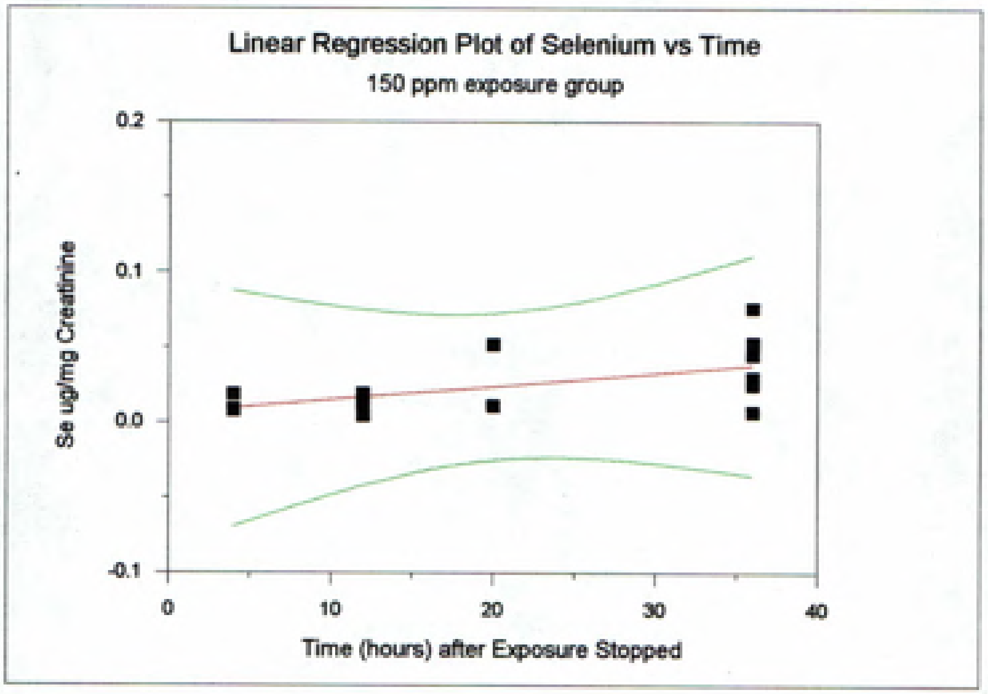

Linear Regression Plot of Iodine vs Time
50 ppm exposure group
I ug/mg Creatinine
9
6
3
0
-3
-6
0
10
20
30
40
Time (hours) after Exposure Stopped

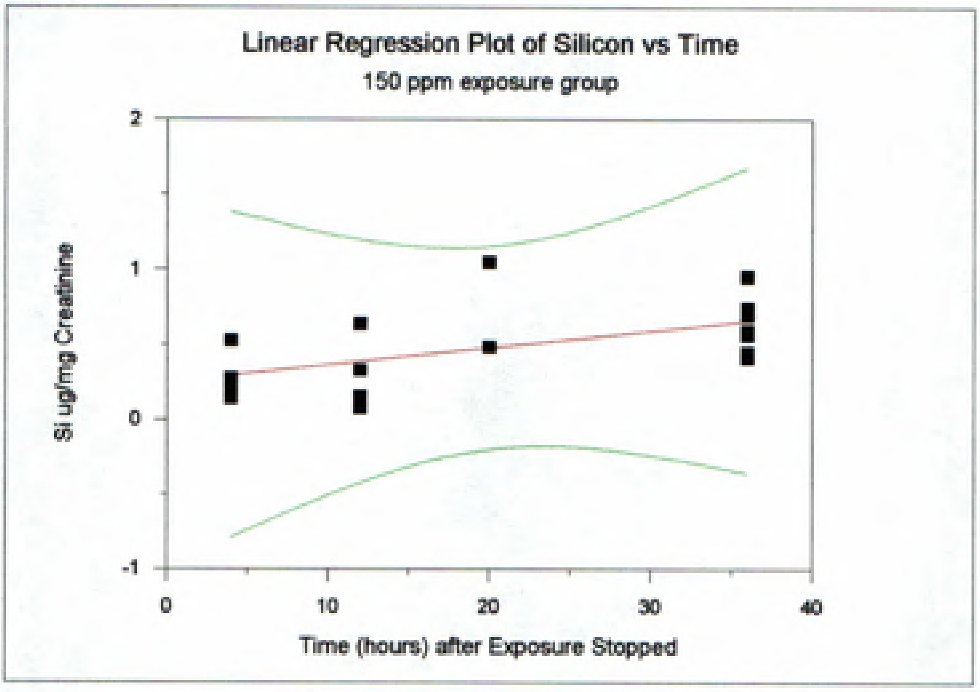


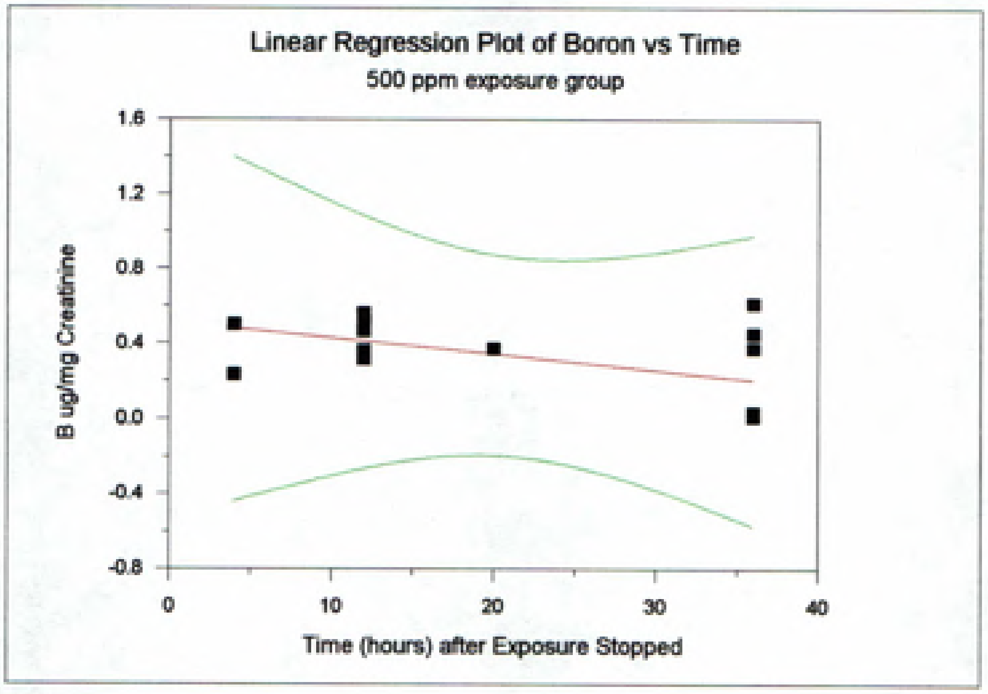
Linear Regression Plot of Magnesium vs Time
50 ppm exposure group
Mg ug/mg Creatinine
90
60
30
0
-30
-60
0
10
20
30
40
Time (hours) after Exposure Stopped

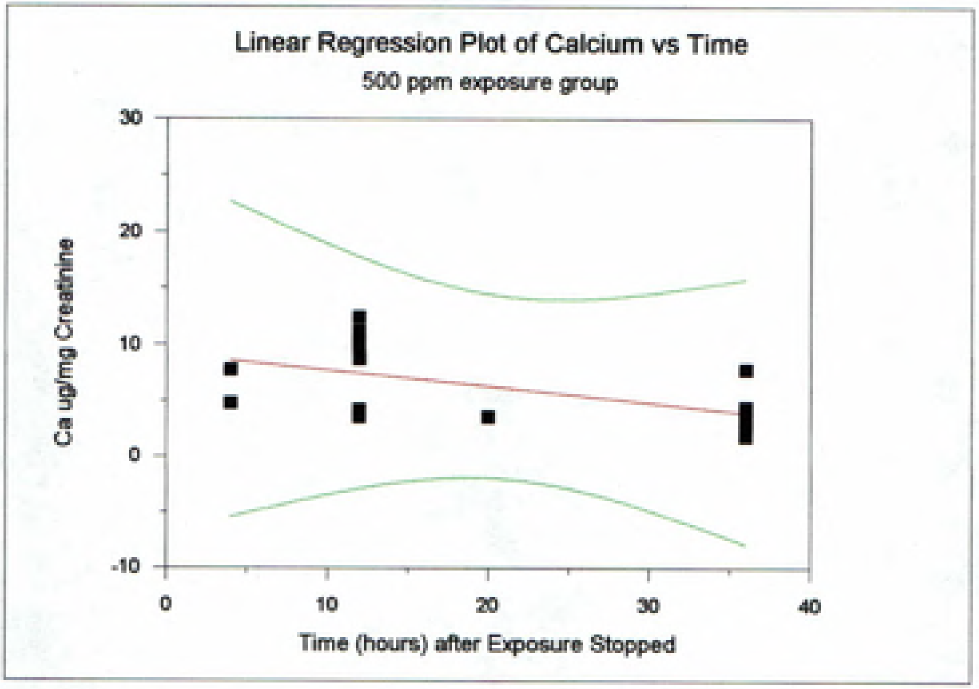

Linear Regression Plot of Manganese vs Time
50 ppm exposure group
Mn ug/mg Creatinine
0.06
0.04
0.02
0.00
-0.02
0
10
20
30
40
Time (hours) after Exposure stopped

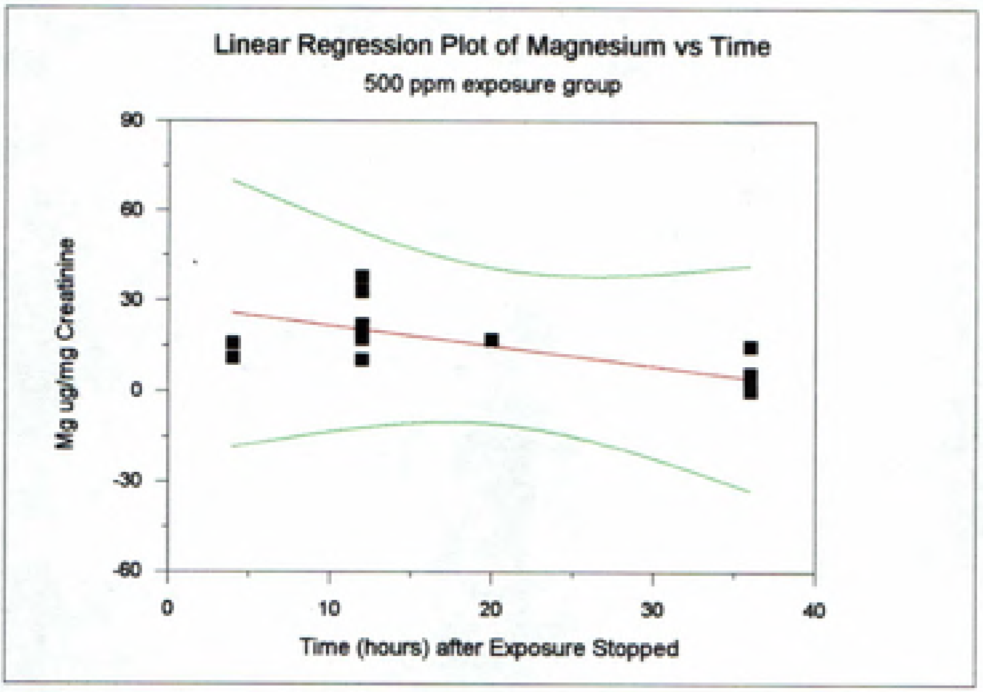

Linear Regression Plot of Phosphorus vs Time
50 ppm exposure group
600
400
200
0
-200
P ug/mg Creatinine
0
10
20
30
40
Time (hours) after Exposure Stopped


Linear Regression Plot of Selenium vs Time
150 ppm exposure group
Se ug/mg Creatinine
0.2
0.1
0.0
-0.1
0
10
20
30
40
Time (hours) after Exposure Stopped

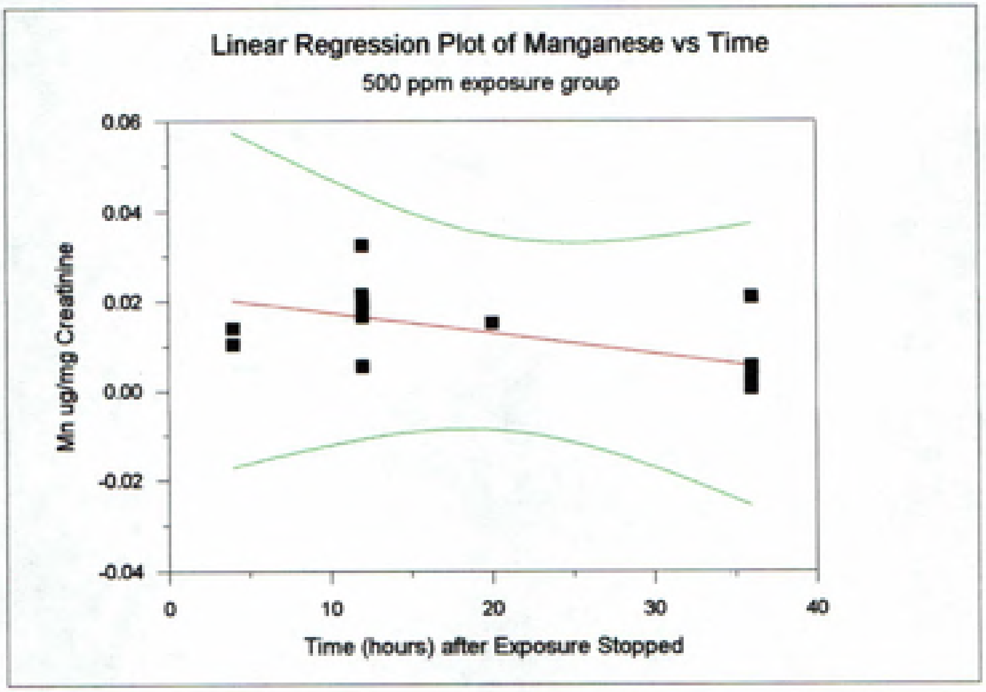

Linear Regression Plot of Silicon vs Time
150 ppm exposure group
Si ug/mg Creatinine
Time (hours) after Exposure Stopped
2
1
0
-1
0
10
20
30
40

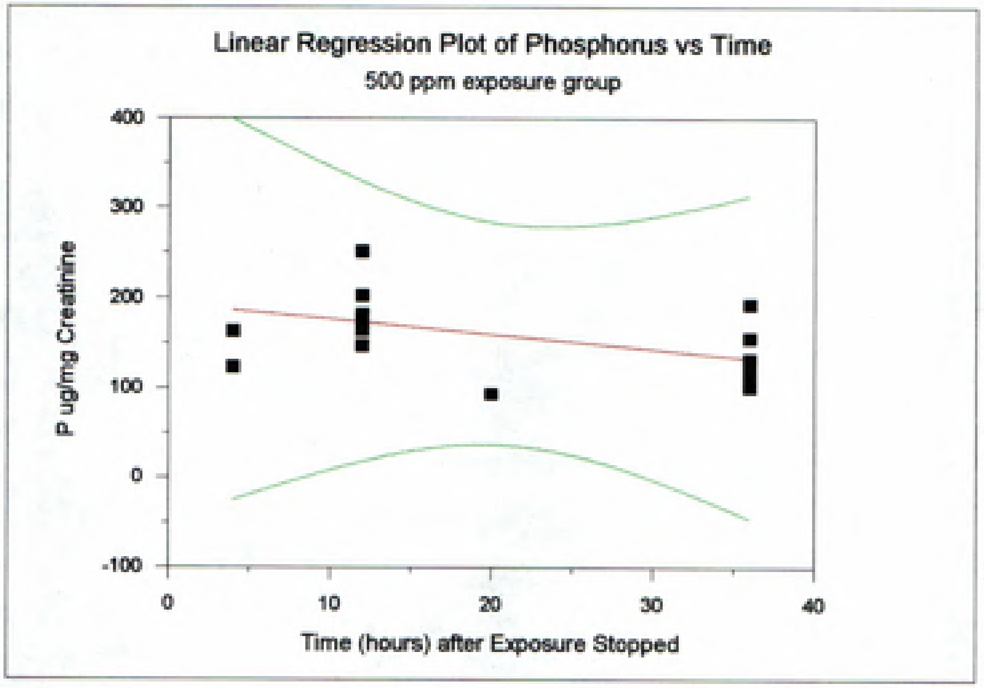

Linear Regression Plot of Boron vs Time
500 ppm exposure group
B ug/mg Creatinine
1.6
1.2
0.8
0.4
0.0
-0.4
-0.8
0
10
20
30
40
Time (hours) after Exposure Stopped

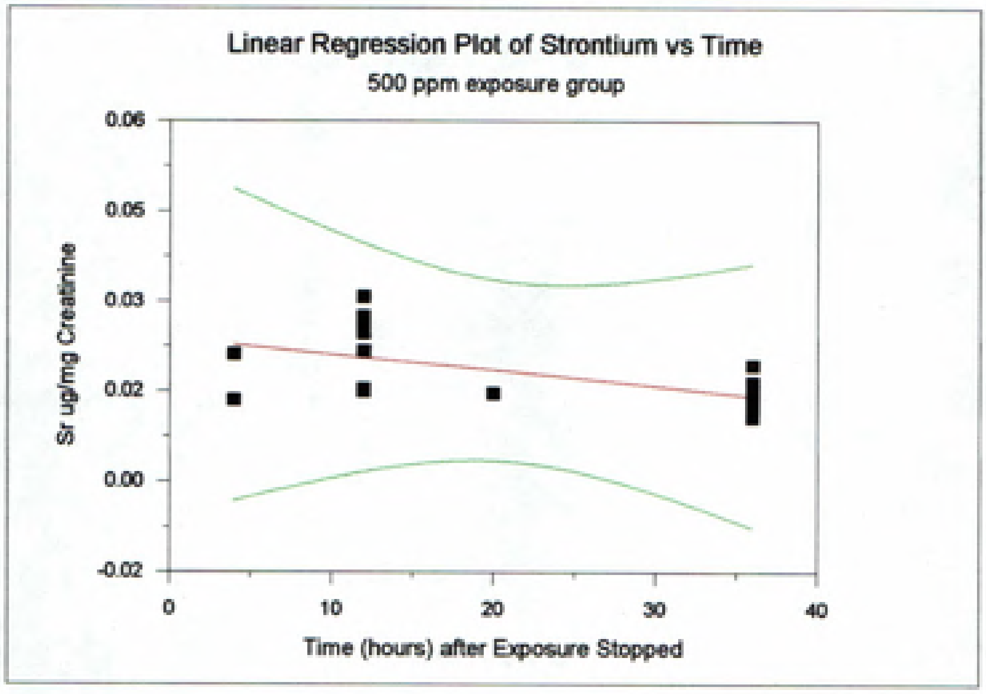

Linear Regression Plot of Calcium vs Time
500 ppm exposure group
Ca ug/mg Creatinine
Time (hours) after Exposure Stopped
30
20
10
0
-10
0
10
20
30
40



Linear Regression Plot of Magnesium vs Time
500 ppm exposure group
Mg ug/mg Creatinine
90
60
30
0
-30
-60
0
10
20
30
40
Time (hours) after Exposure Stopped

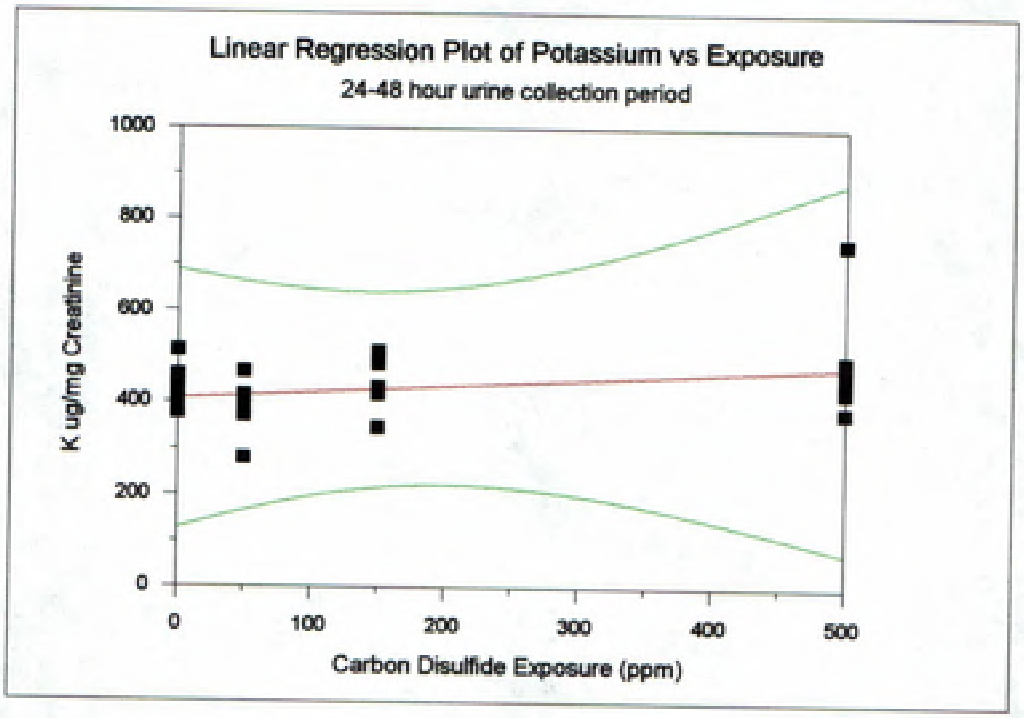

Linear Regression Plot of Manganese vs Time
500 ppm exposure group
Mn ug/mg Creatinine
0.06
0.04
0.02
0.00
-0.02
-0.04
0
10
20
30
40
Time (hours) after Exposure Stopped

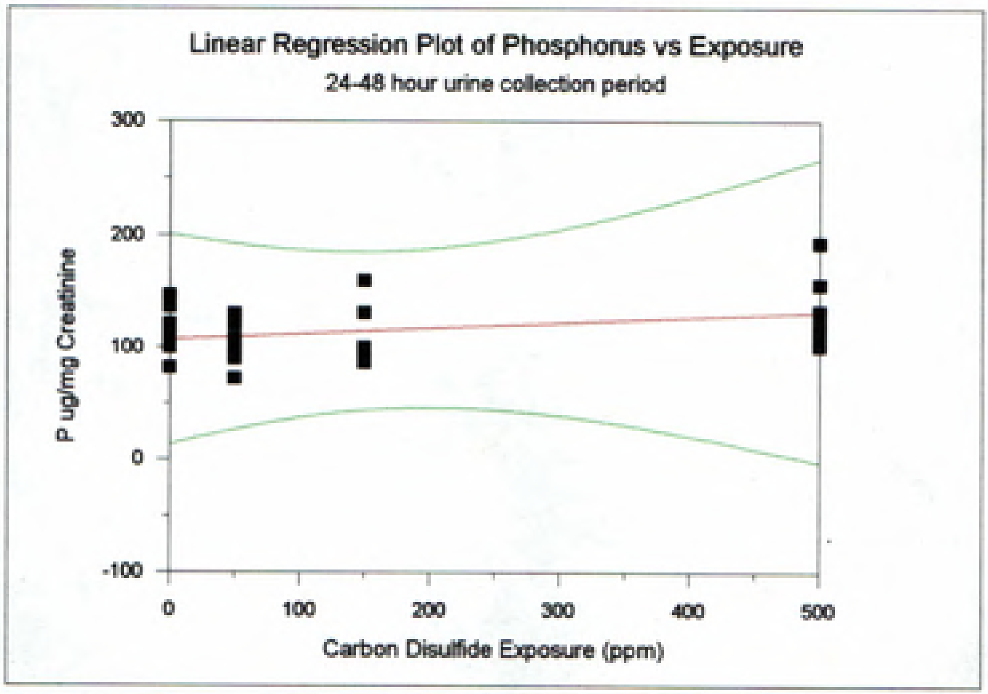

Linear Regression Plot of Phosphorus vs Time
500 ppm exposure group
P ug/mg Creatinine
400
300
200
100
0
-100
0
10
20
30
40
Time (hours) after Exposure Stopped

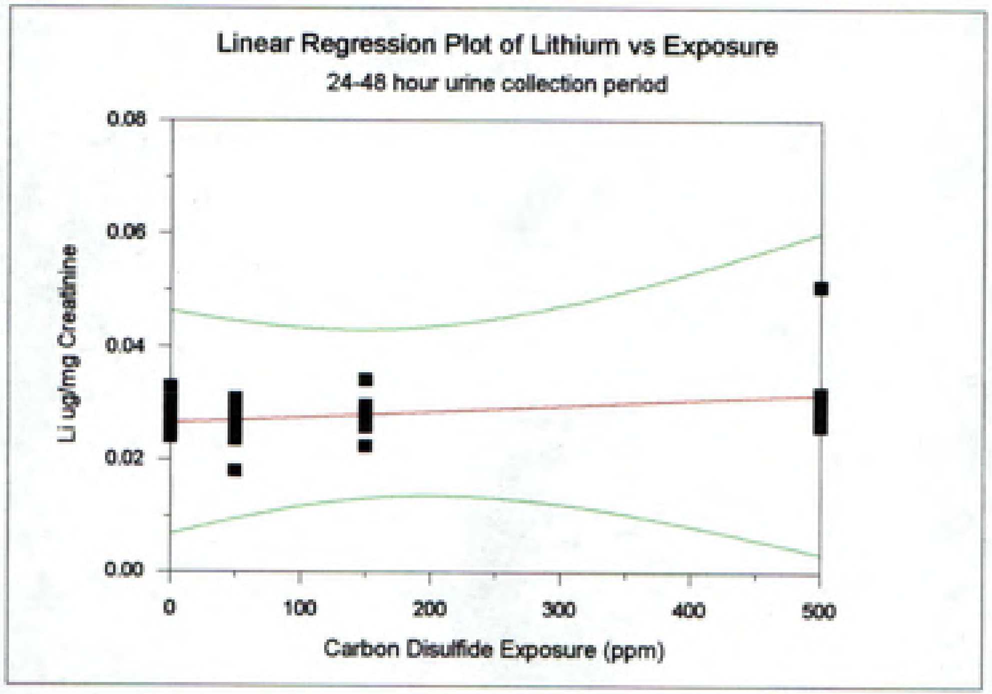


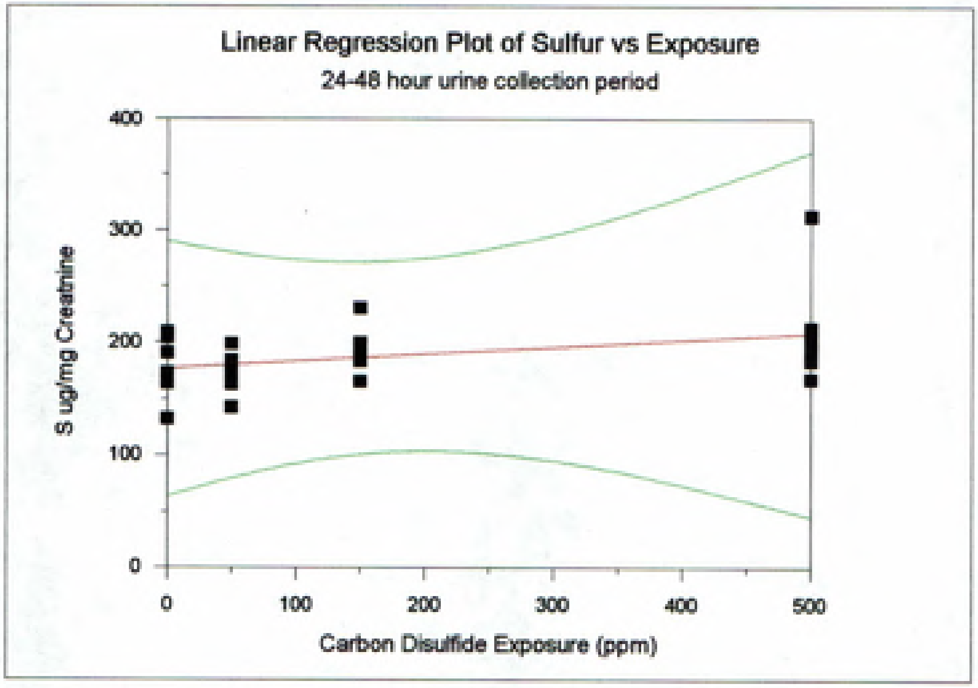
Linear Regression Plot of Strontium vs Time
500 ppm exposure group
0.06
0.05
0.03
0.02
0.00
-0.02
Sr ug/mg Creatinine
0
10
20
30
40
Time (hours) after Exposure Stopped

7.4 Appendix D ---- Linear regression plots of metal (μg/mg) vs CS_2 exposure

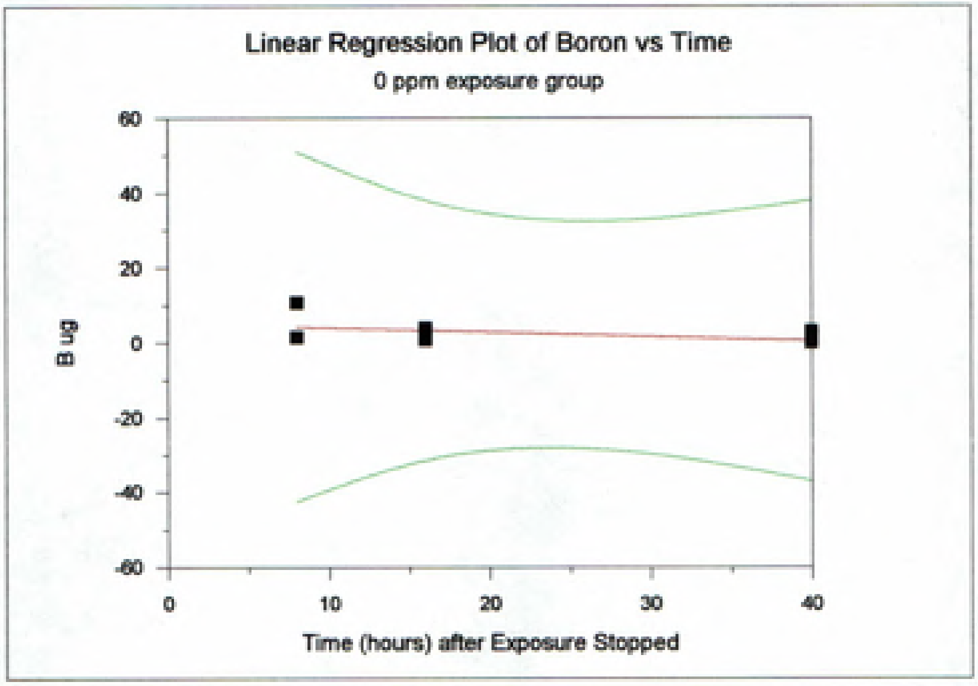

Linear Regression Plot of Potassium vs Exposure
24-48 hour urine collection period
K ug/mg Creatinine
0
200
400
600
800
1000
0
100
200
300
400
500
Carbon Disulfide Exposure (ppm)


Linear Regression Plot of Phosphorus vs Exposure
24-48 hour urine collection period
300
200
100
0
-100
P ug/mg Creatinine
0
100
200
300
400
500
Carbon Disulfide Exposure (ppm)

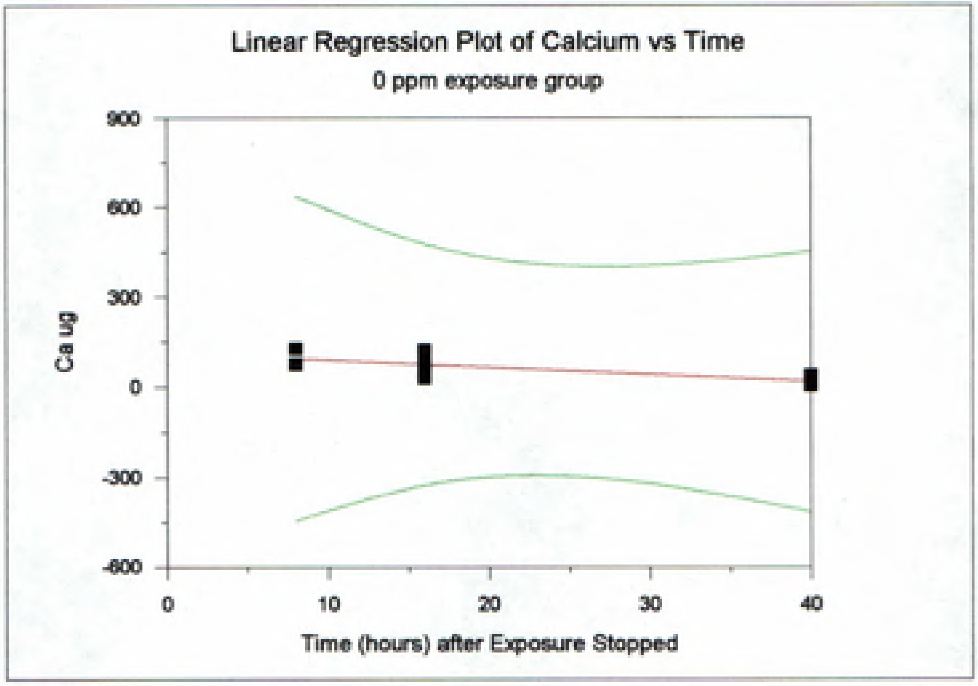

Linear Regression Plot of Lithium vs Exposure
24-48 hour urine collection period
0.08
0.06
0.04
0.02
0.00
Li ug/mg Creatinine
0
100
200
300
400
500
Carbon Disulfide Exposure (ppm)


Linear Regression Plot of Sulfur vs Exposure
24-48 hour urine collection period
S ug/mg Creatnine
Carbon Disulfide Exposure (ppm)
0
100
200
300
400
500

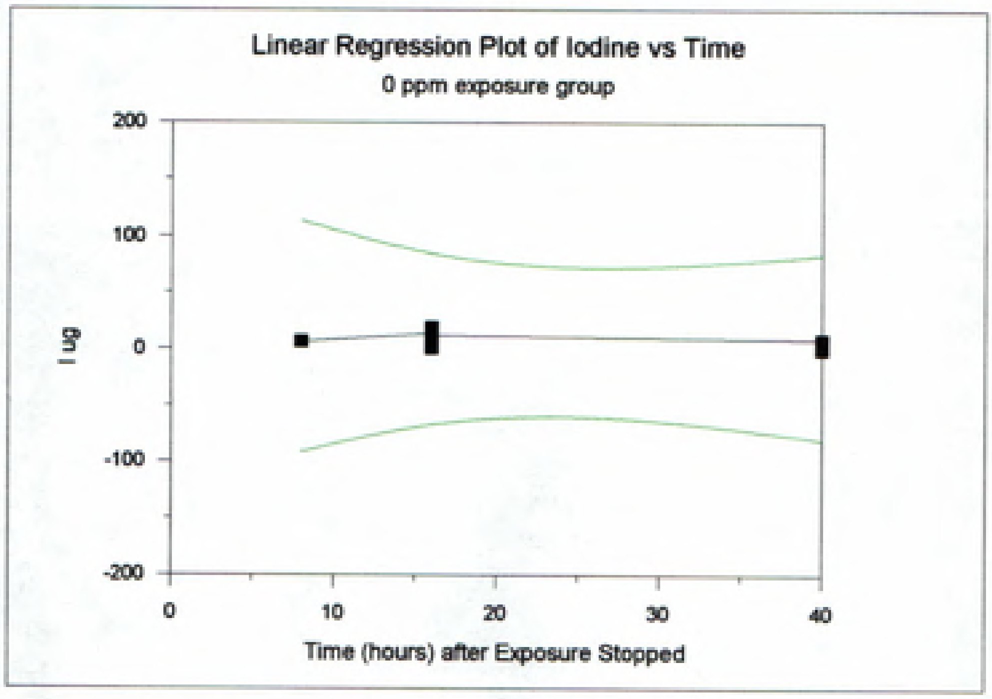
7.5 Appendix E ---- Linear regression plots of metal (μg) vs time

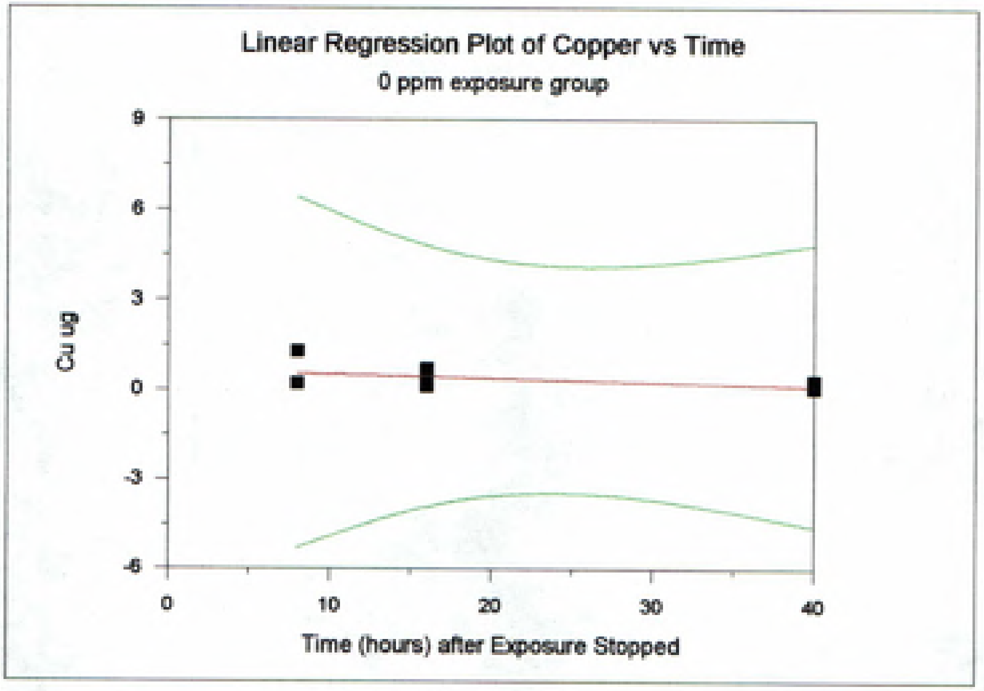


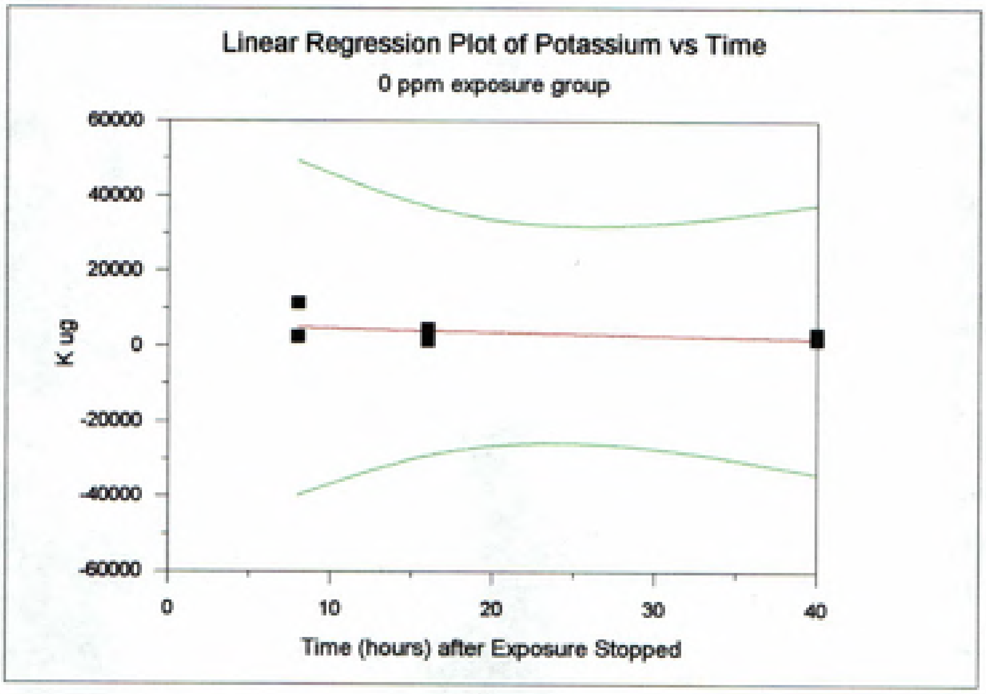
Linear Regression Plot of Boron vs Time
0 ppm exposure group
60
40
20
0
-20
-40
-60
B ug
0
10
20
30
40
Time (hours) after Exposure Stopped

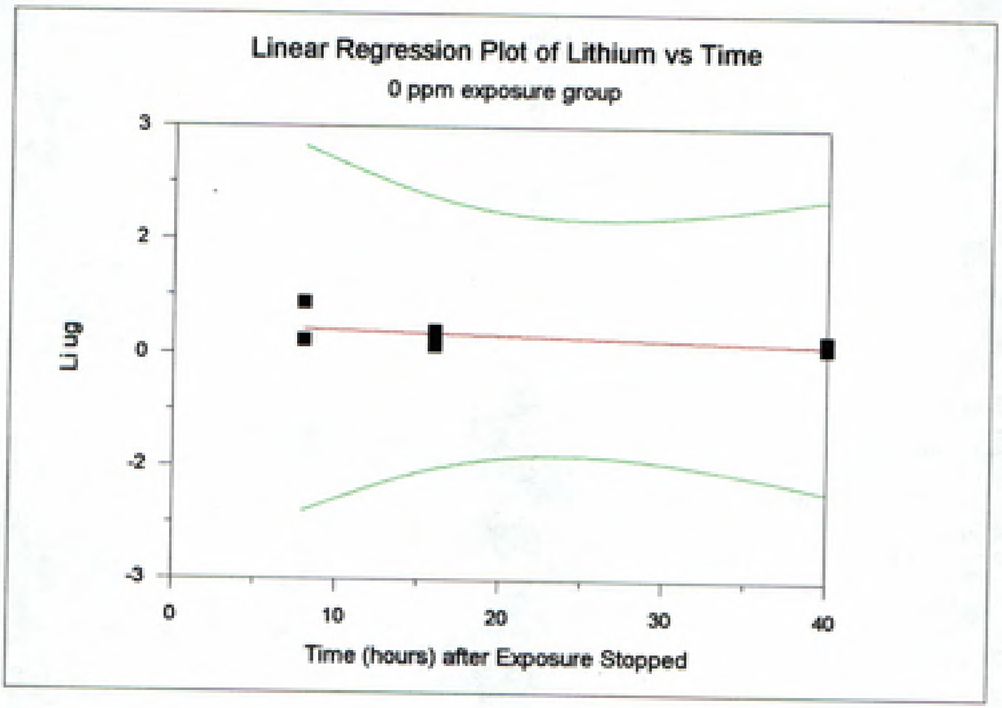


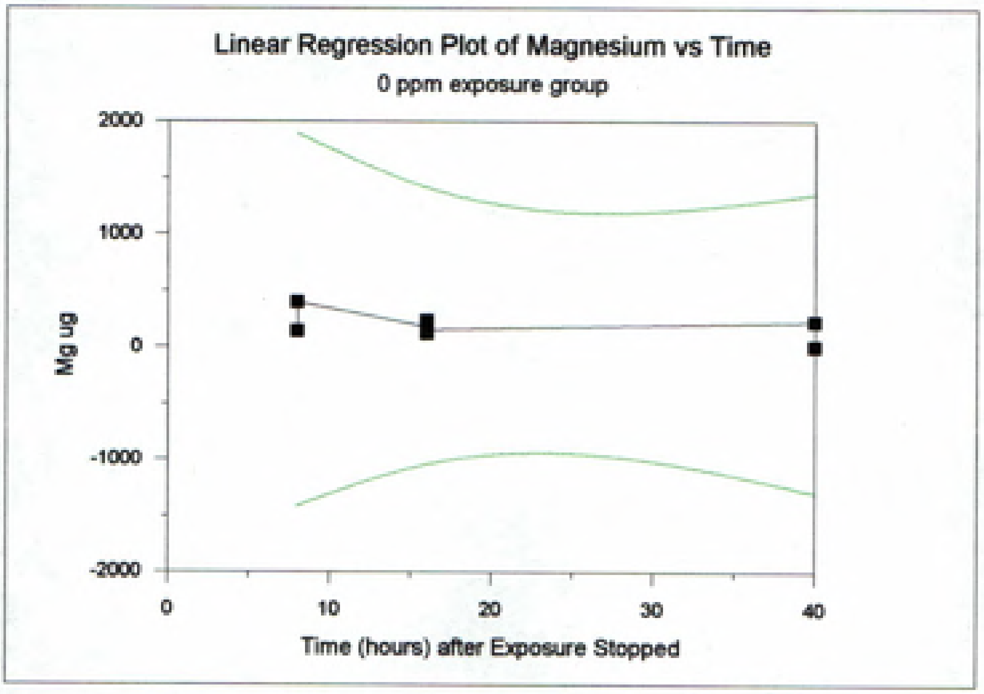
Linear Regression Plot of Calcium vs Time
0 ppm exposure group
900
600
300
0
-300
-600
Ca ug
0
10
20
30
40
Time (hours) after Exposure Stopped

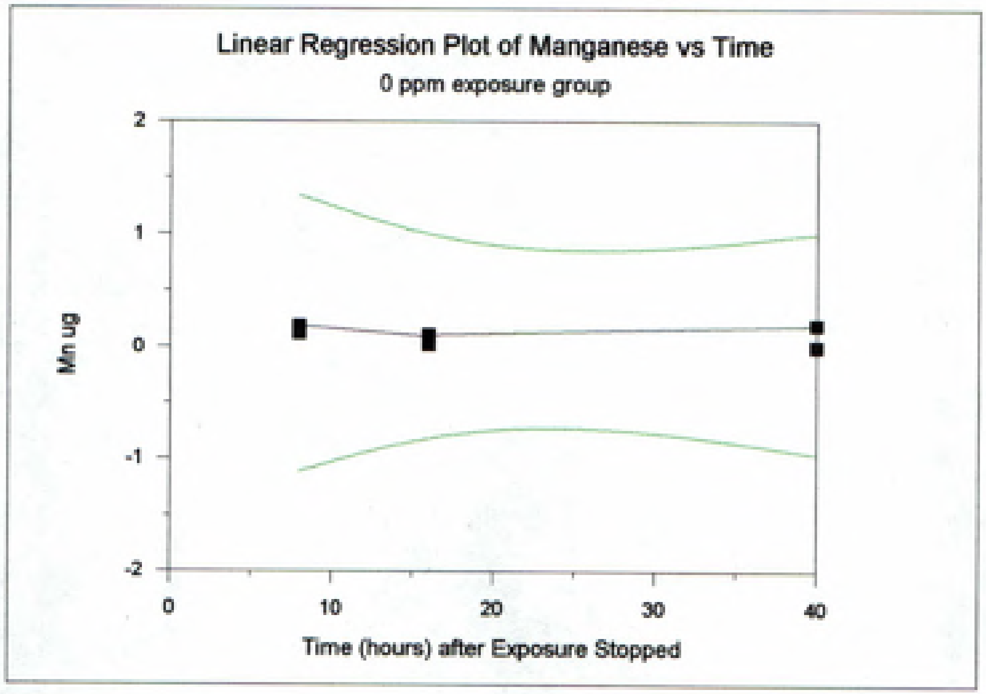

Linear Regression Plot of Iodine vs Time
0 ppm exposure group
200
100
0
-100
-200
I ug
0
10
20
30
40
Time (hours) after Exposure Stopped

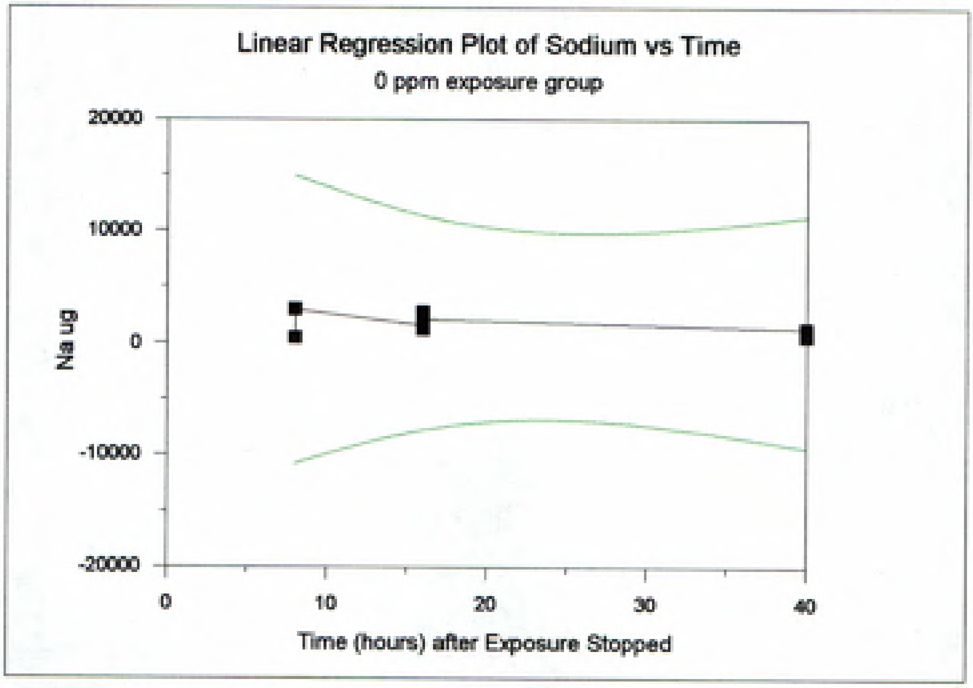

Linear Regression Plot of Copper vs Time
0 ppm exposure group
9
6
3
0
-3
-6
Cu ug
0
10
20
30
40
Time (hours) after Exposure Stopped

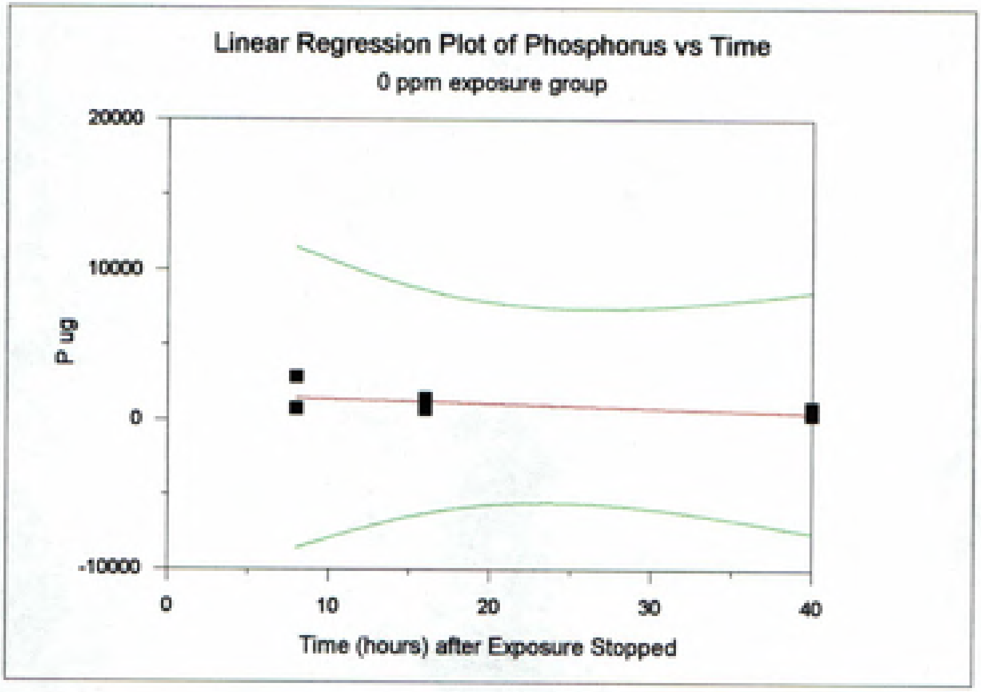

Linear Regression Plot of Potassium vs Time
0 ppm exposure group
60000
40000
20000
0
-20000
-40000
-60000
K ug
0
10
20
30
40
Time (hours) after Exposure Stopped


Linear Regression Plot of Lithium vs Time
0 ppm exposure group
Li ug
3
2
0
-2
-3
0
10
20
30
40
Time (hours) after Exposure Stopped

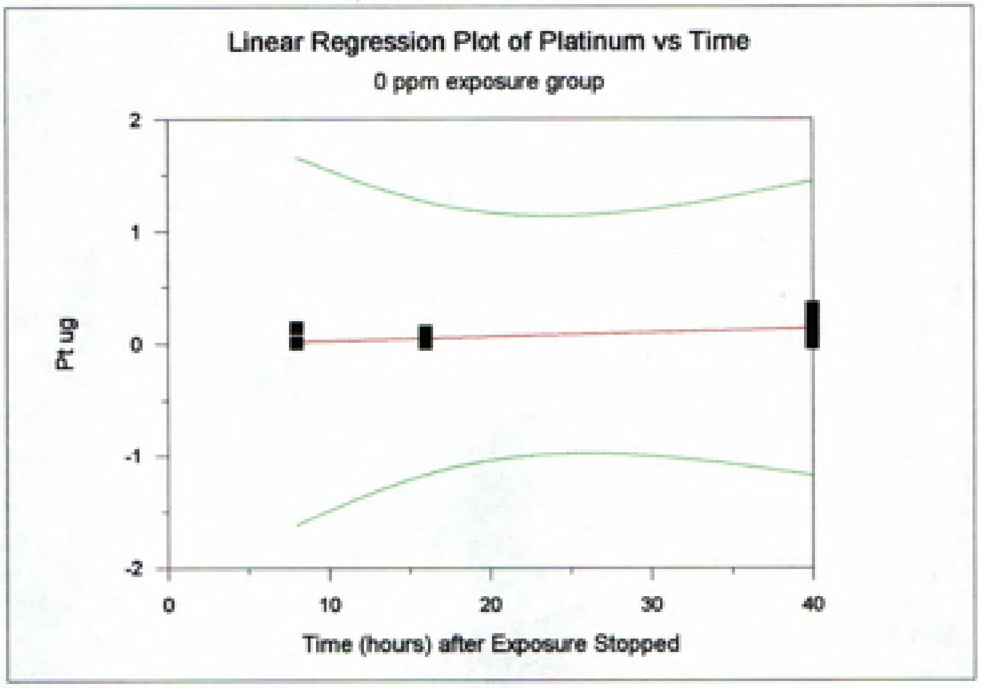

Linear Regression Plot of Magnesium vs Time
0 ppm exposure group
2000
1000
0
-1000
-2000
Mg ug
0
10
20
30
40
Time (hours) after Exposure Stopped

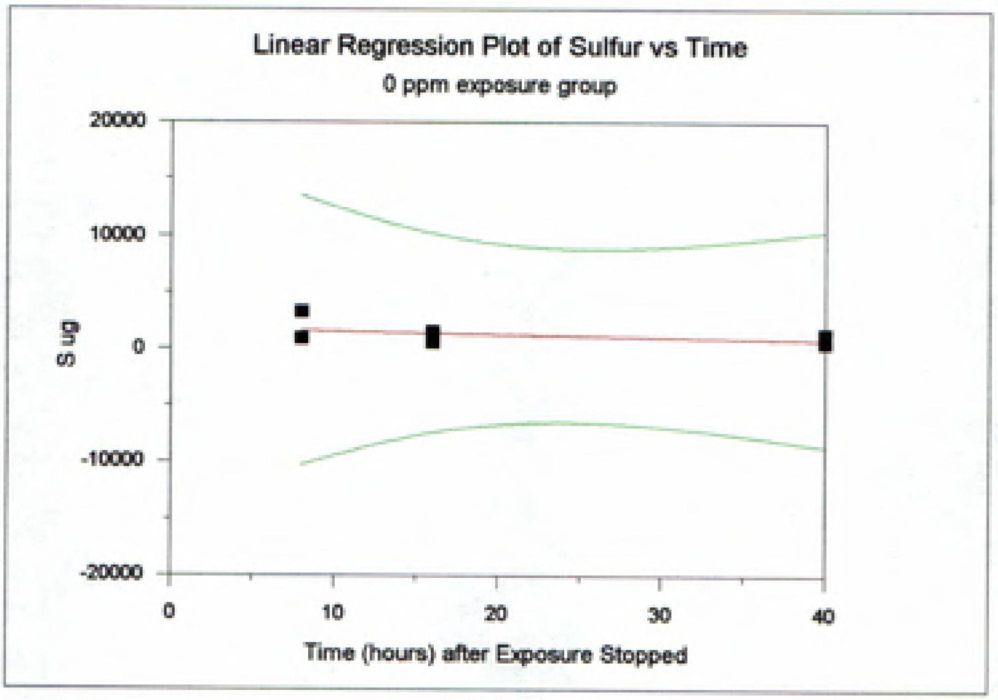

Linear Regression Plot of Manganese vs Time
0 ppm exposure group
2
1
0
-1
-2
Mn ug
0
10
20
30
40
Time (hours) after Exposure Stopped

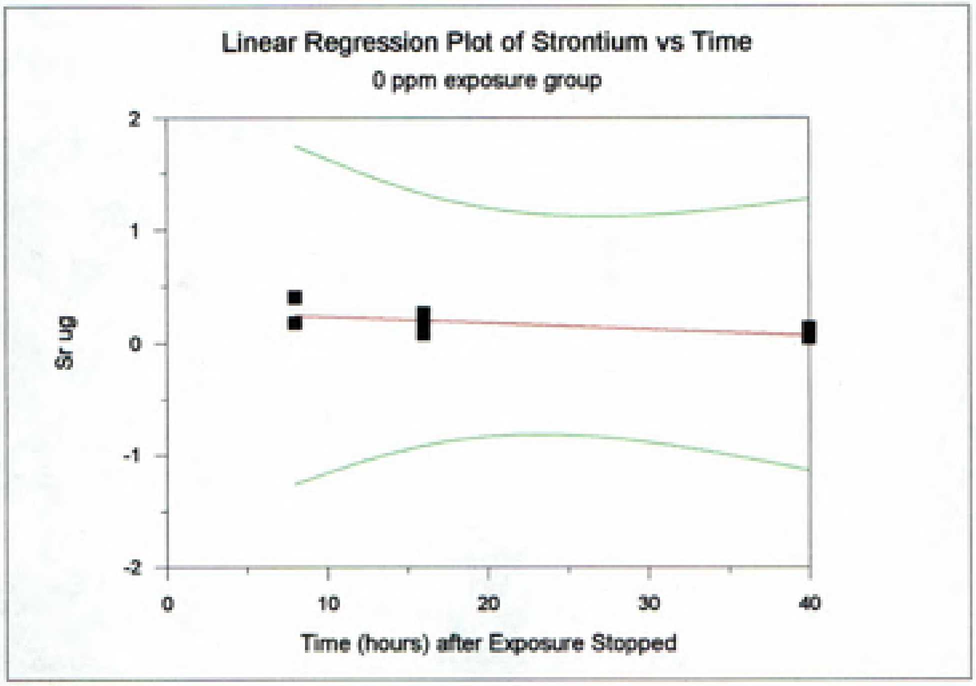

Linear Regression Plot of Sodium vs Time
0 ppm exposure group
20000
10000
0
-10000
-20000
Na ug
0
10
20
30
40
Time (hours) after Exposure Stopped

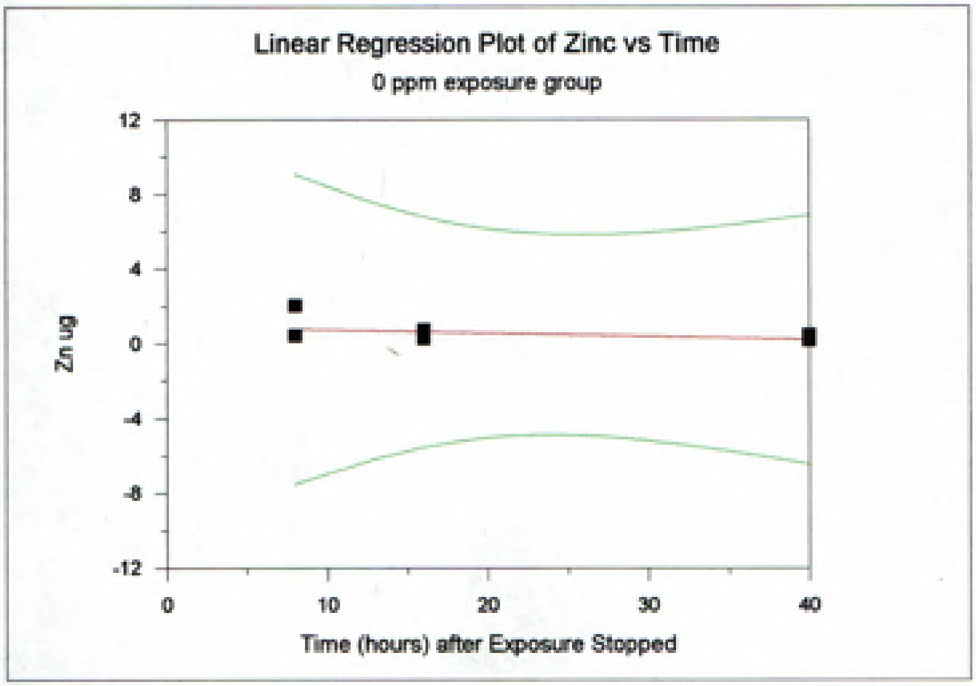


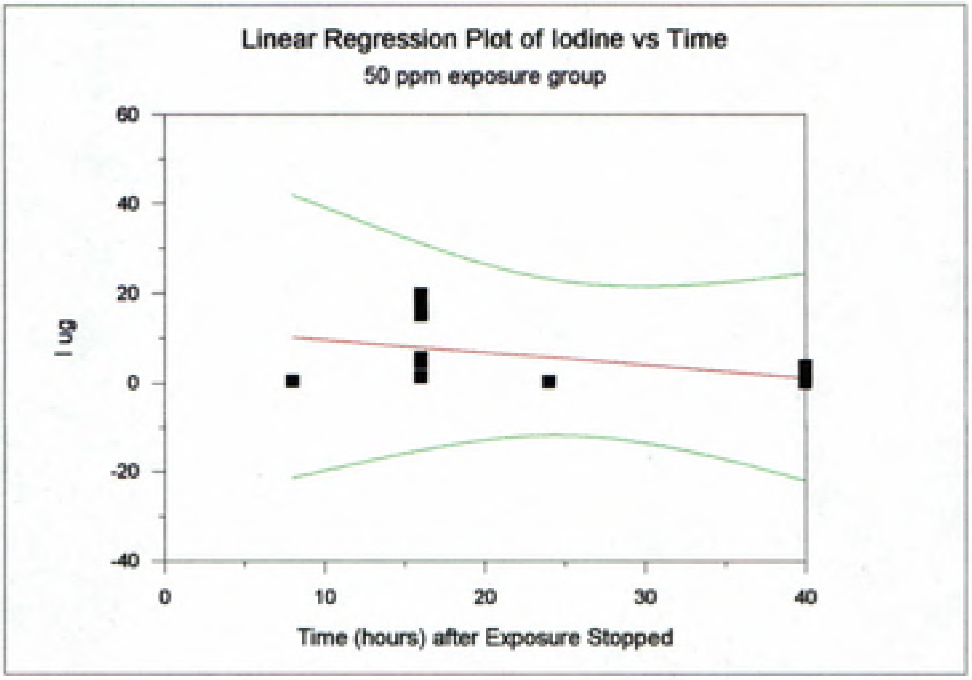
Linear Regression Plot of Phosphorus vs Time
0 ppm exposure group
20000
10000
0
-10000
P ug
0
10
20
30
40
Time (hours) after Exposure Stopped


Linear Regression Plot of Platinum vs Time
0 ppm exposure group
Pt ug
2
1
0
-1
-2
0
10
20
30
40
Time (hours) after Exposure Stopped

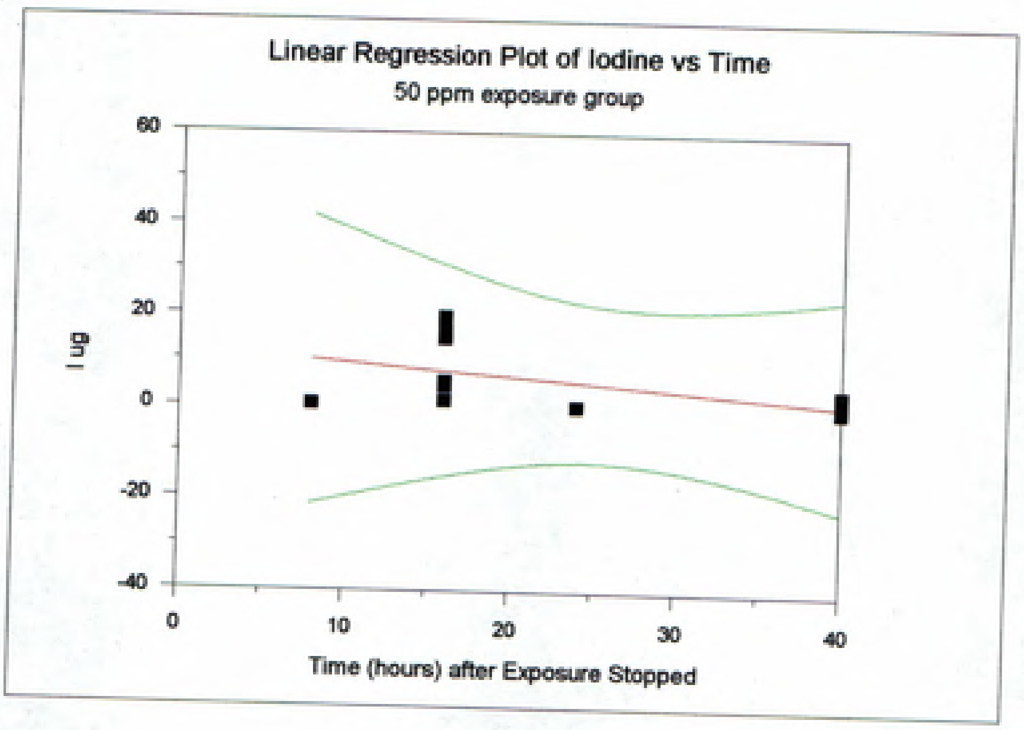

Linear Regression Plot of Sulfur vs Time
0 ppm exposure group
20000
10000
0
-10000
-20000
S ug
0
10
20
30
40
Time (hours) after Exposure Stopped

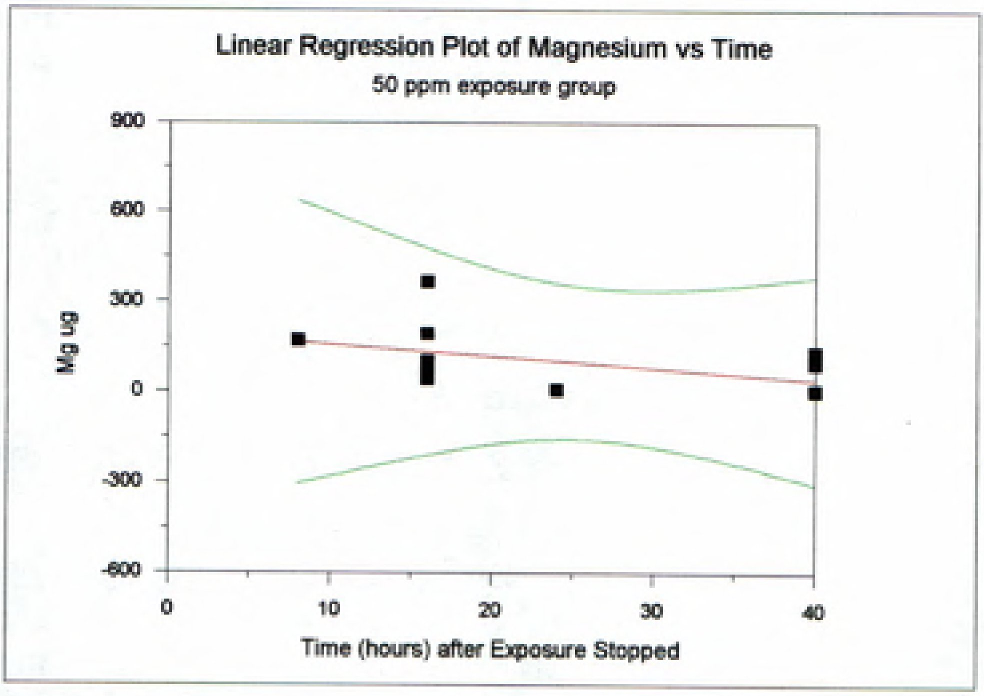

Linear Regression Plot of Strontium vs Time
0 ppm exposure group
Sr ug
2
1
0
-1
-2
0
10
20
30
40
Time (hours) after Exposure Stopped

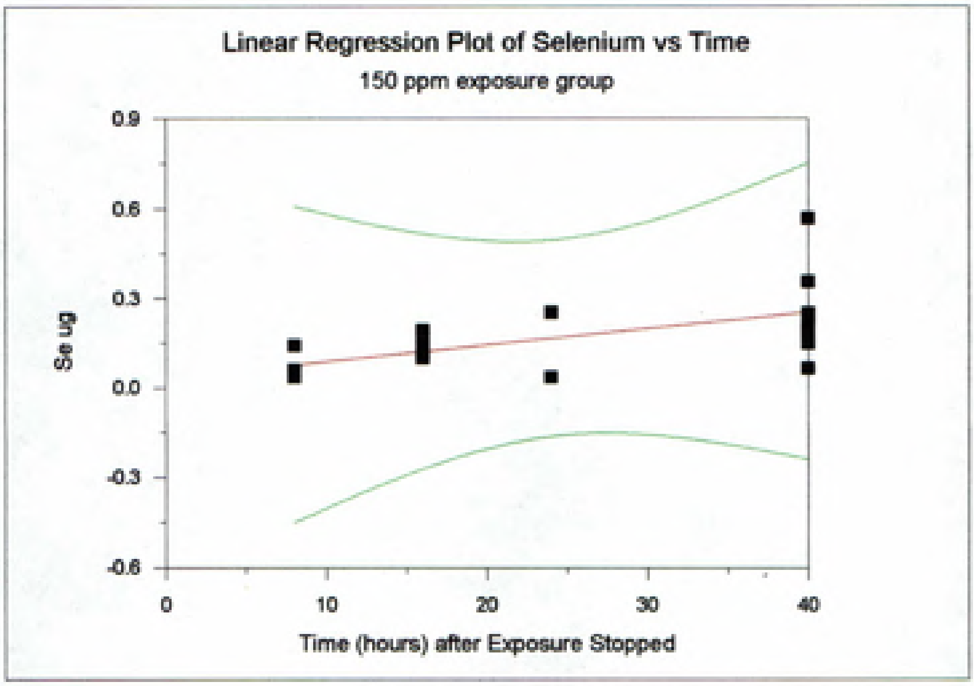

Linear Regression Plot of Zinc vs Time
0 ppm exposure group
12
8
4
0
-4
-8
-12
Zn ug
0
10
20
30
40
Time (hours) after Exposure Stopped

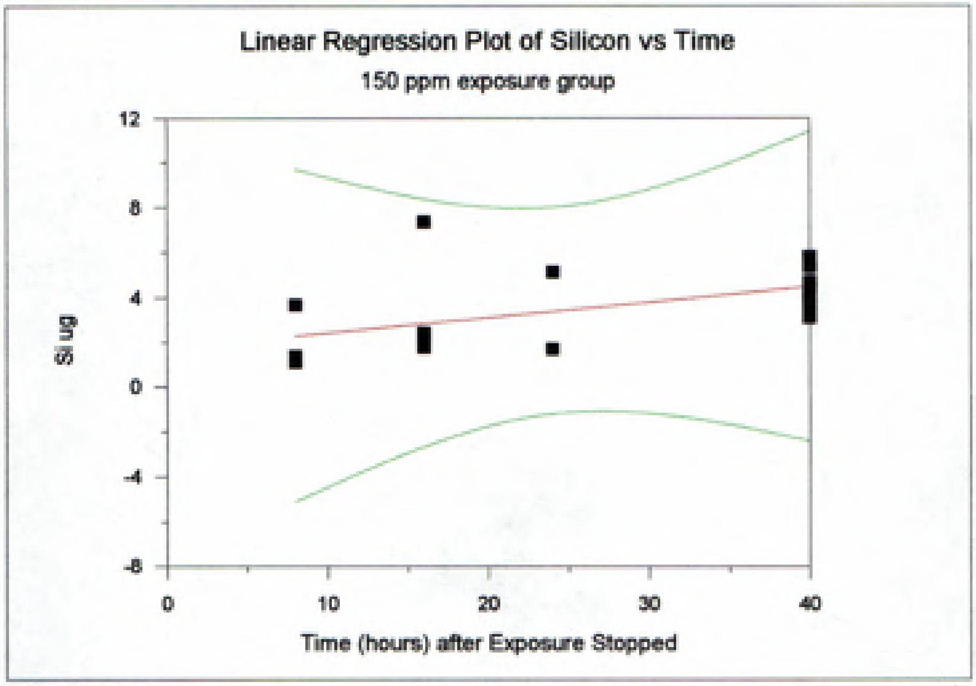


Linear Regression Plot of Iodine vs Time
50 ppm exposure group
60
40
20
0
-20
-40
I ug
0
10
20
30
40
Time (hours) after Exposure Stopped

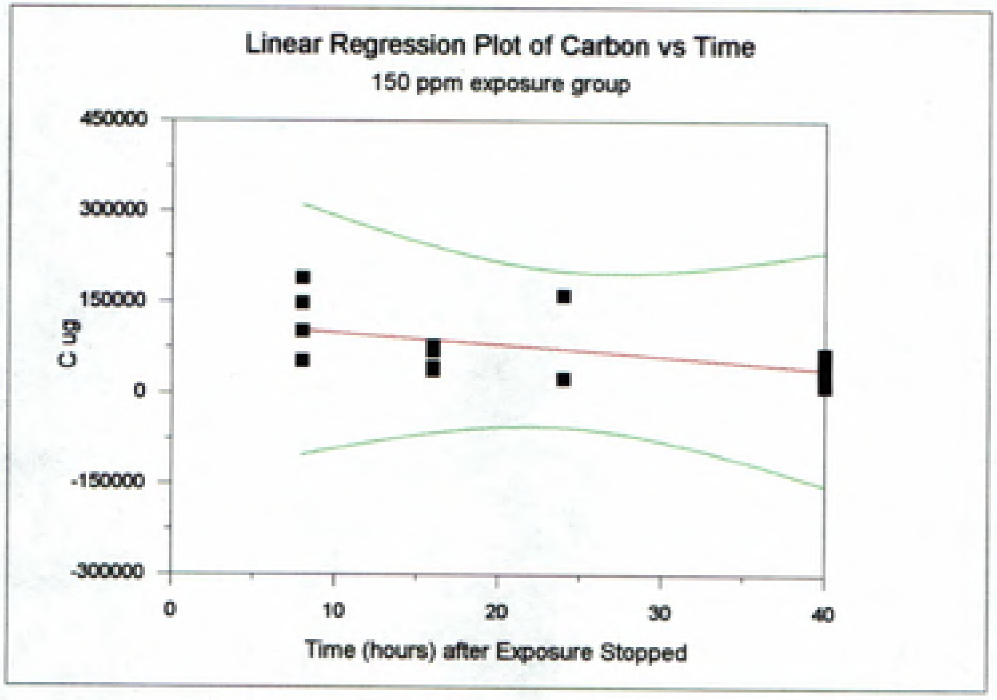

Linear Regression Plot of Iodine vs Time
50 ppm exposure group
60
40
20
0
-20
-40
I ug
0
10
20
30
40
Time (hours) after Exposure Stopped

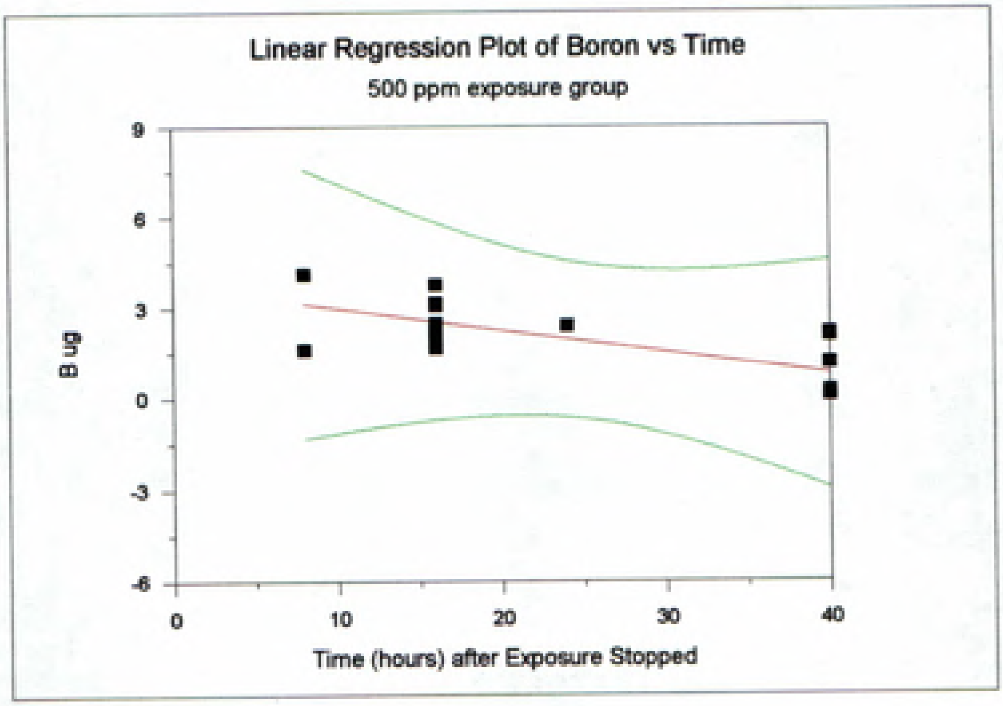

Linear Regression Plot of Magnesium vs Time
50 ppm exposure group
900
600
300
0
-300
-600
Mg ug
0
10
20
30
40
Time (hours) after Exposure Stopped

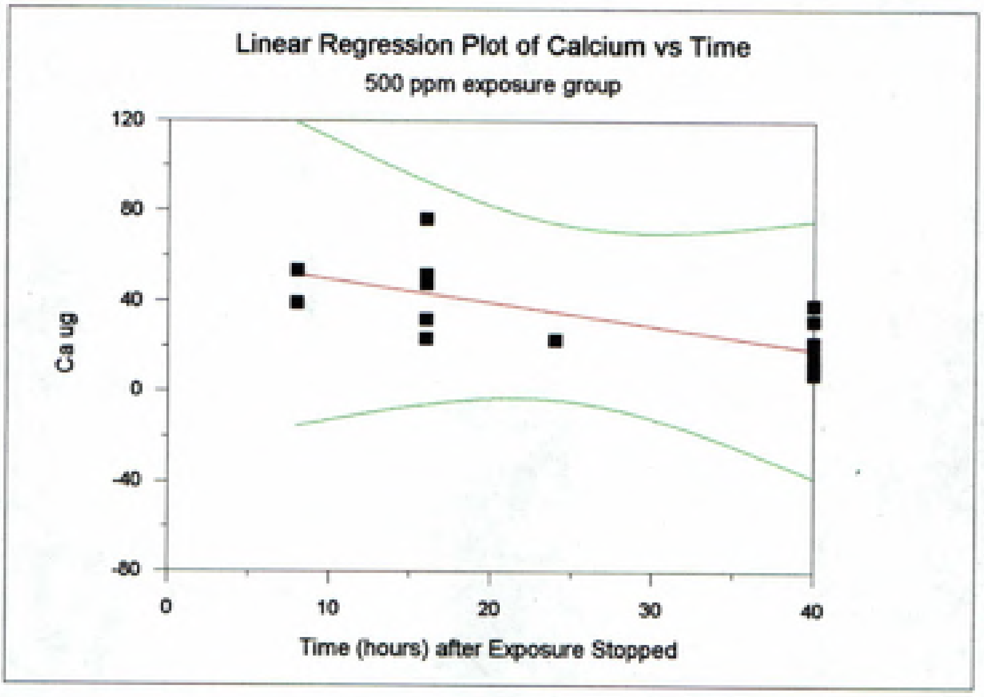

Linear Regression Plot of Selenium vs Time
150 ppm exposure group
Se ug
0.9
0.6
0.3
0.0
-0.3
-0.6
0
10
20
30
40
Time (hours) after Exposure Stopped

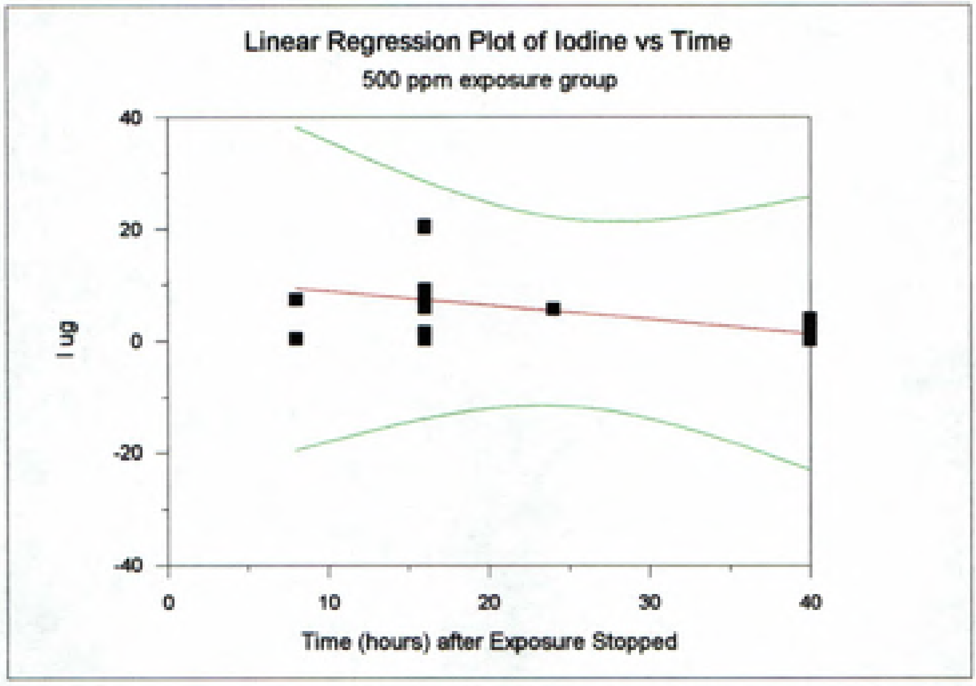


Linear Regression Plot of Silicon vs Time
150 ppm exposure group
Si ug
12
8
4
0
-4
-8
0
10
20
30
40
Time (hours) after Exposure Stopped

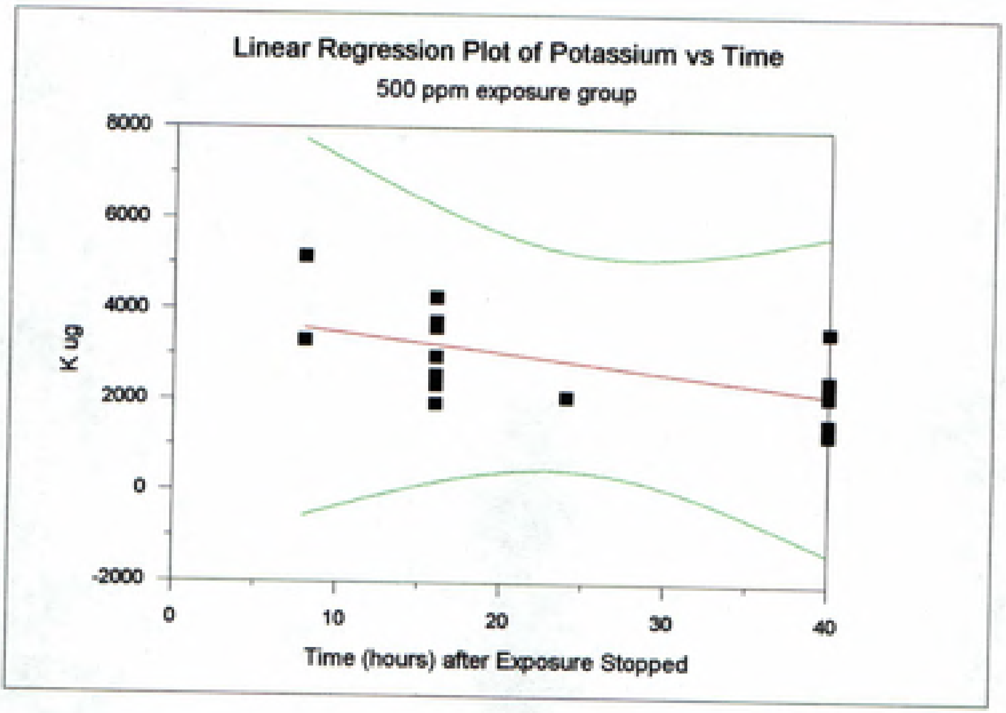

Linear Regression Plot of Carbon vs Time
150 ppm exposure group
450000
300000
150000
0
-150000
-300000
C ug
0
10
20
30
40
Time (hours) after Exposure Stopped

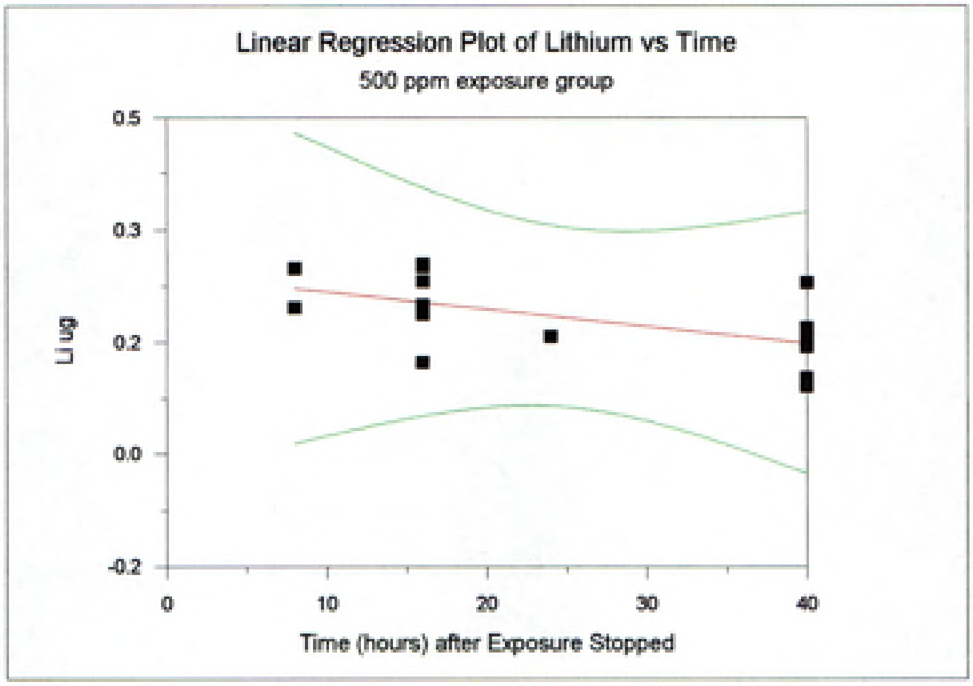

Linear Regression Plot of Boron vs Time
500 ppm exposure group
B ug
9
6
3
0
-3
-6
0
10
20
30
40
Time (hours) after Exposure Stopped

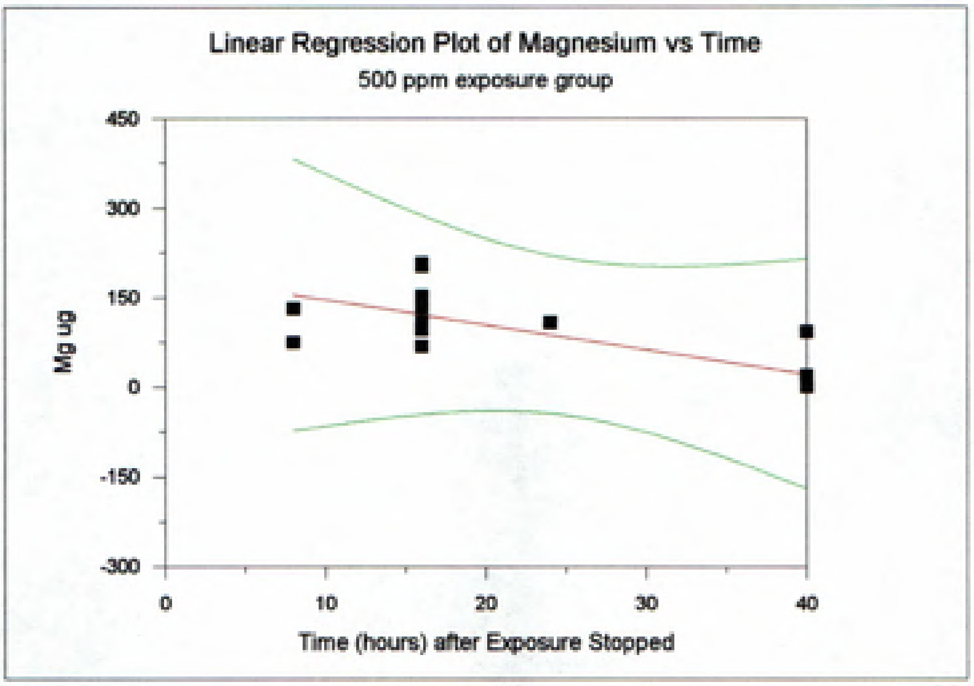

Linear Regression Plot of Calcium vs Time
500 ppm exposure group
Ca ug
120
80
40
0
-40
-80
0
10
20
30
40
Time (hours) after Exposure Stopped

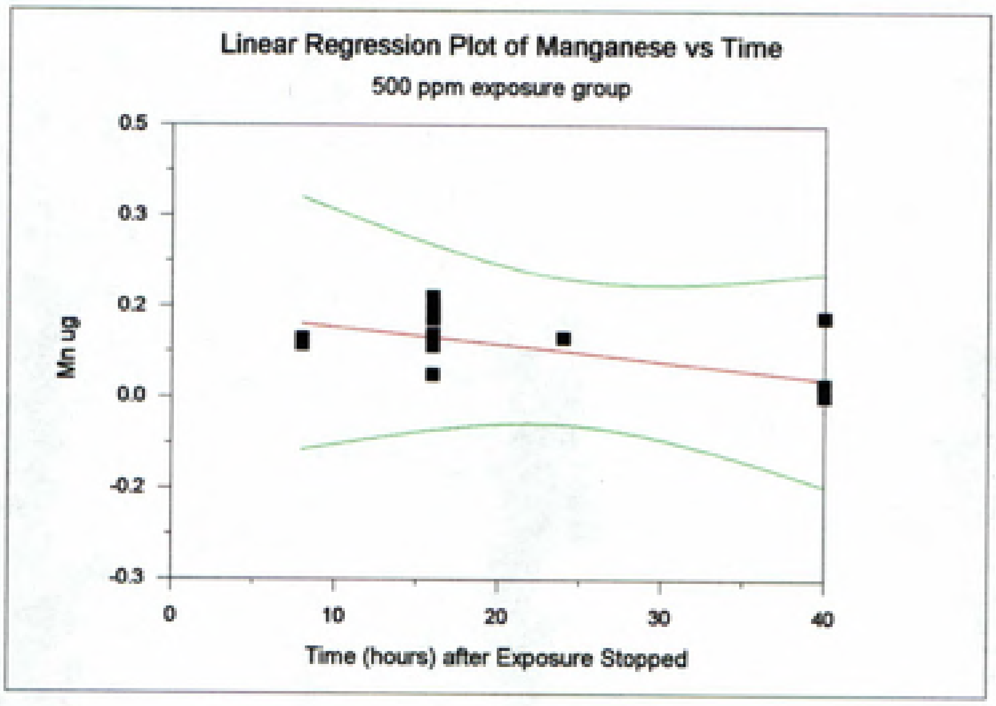


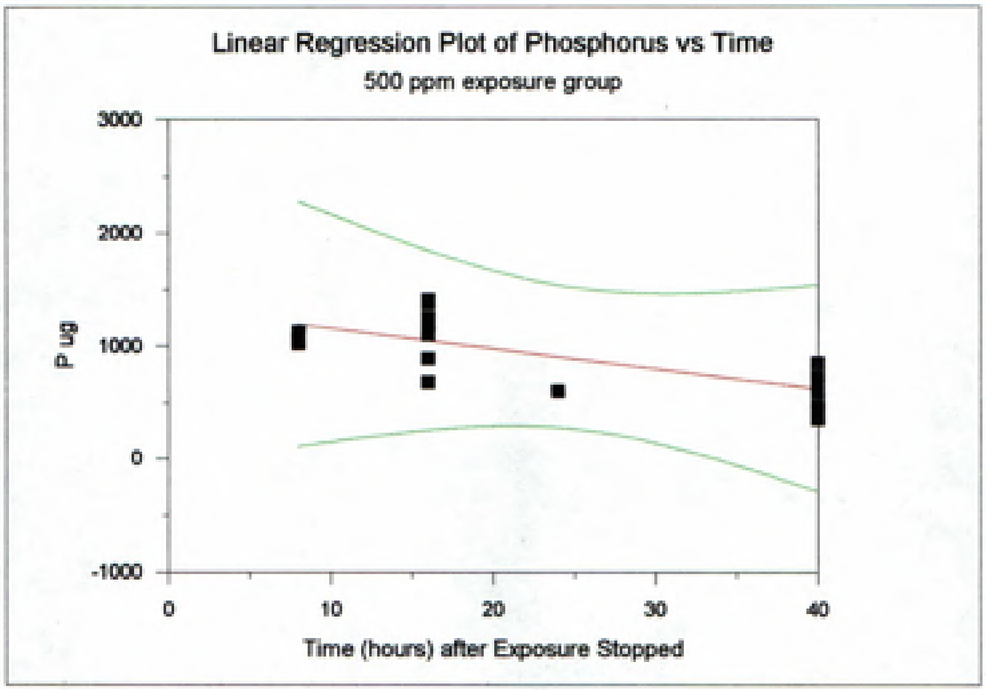
Linear Regression Plot of Iodine vs Time
500 ppm exposure group
40
20
0
-20
-40
I ug
0
10
20
30
40
Time (hours) after Exposure Stopped

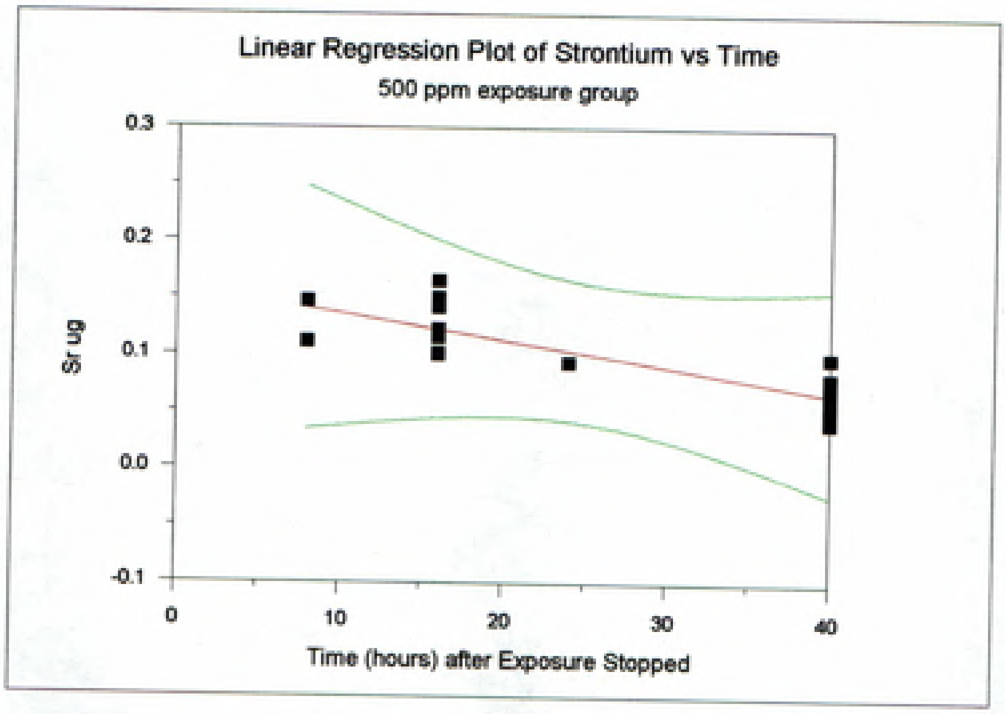

Linear Regression Plot of Potassium vs Time
500 ppm exposure group
8000
6000
4000
2000
0
-2000
K ug
0
10
20
30
40
Time (hours) after Exposure Stopped


Linear Regression Plot of Lithium vs Time
500 ppm exposure group
Li ug
0.5
0.3
0.2
0.0
-0.2
0
10
20
30
40
Time (hours) after Exposure Stopped

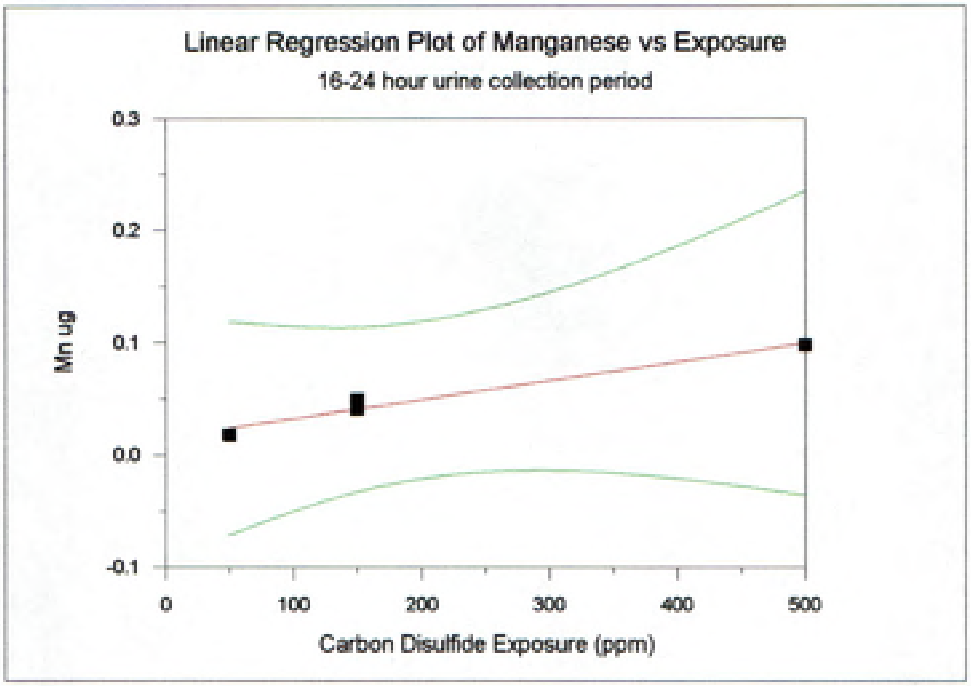

Linear Regression Plot of Magnesium vs Time
500 ppm exposure group
450
300
150
0
-150
-300
Mg ug
0
10
20
30
40
Time (hours) after Exposure Stopped


Linear Regression Plot of Manganese vs Time
500 ppm exposure group
Mn ug
0.5
0.3
0.2
0.0
-0.2
-0.3
0
10
20
30
40
Time (hours) after Exposure Stopped


Linear Regression Plot of Phosphorus vs Time
500 ppm exposure group
3000
2000
1000
0
-1000
P ug
0
10
20
30
40
Time (hours) after Exposure Stopped


Linear Regression Plot of Strontium vs Time
500 ppm exposure group
Sr ug
0.3
0.2
0.1
0.0
-0.1
0
10
20
30
40
Time (hours) after Exposure Stopped

7.6 Appendix F ---- Linear regression plot of metal (µg) vs CS_2 exposure



Linear Regression Plot of Manganese vs Exposure
16-24 hour urine collection period
0.3
0.2
0.1
0.0
-0.1
Mn ug
0
100
200
300
400
500
Carbon Disulfide Exposure (ppm)